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INTERSTATE AIR POLLUTION STUDY. PHASE II PROJECT REPORT. VII. OPINION SURVEYS AND AIR QUALITY STATISTICAL RELATIONSHIPS

J. D. Williams, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

May 1966

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PHASE II PROJECT REPORT

VII. OPINION SURVEYS AND AIR QUALITY STATISTICAL RELATIONSHIPS

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INTERSTATE AIR POLLUTION STUDY
PHASE II PROJECT REPORT

VII. OPINION SURVEYS AND AIR QUALITY STATISTICAL RELATIONSHIPS

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May 1966

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Copies of this report are available from the cooperating agencies listed on the cover of this report and from the Technical Assistance Branch, Division of Air Pollution, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati, Ohio.

FOREWORD

The Interstate Air Pollution Study was divided into two phases. Phase I, a general study of the overall air pollution problems in the St. Louis - East St. Louis Metropolitan area, was conducted to determine specific activities that would require further study in Phase II of the project. The effort was divided into two phases to provide a logical stopping point in the event that interest and resources for proceeding further might not materialize. The necessary impetus did continue, however, and the Phase II operation was also completed.

The Phase I operation resulted in a detailed report, designed primarily for use of the Executive Committee members and their agencies in making decisions concerning the Phase II project operation. A Phase I summary report was also prepared; it received wide distribution.

Numerous papers, brochures, and reports were prepared during Phase II operations, as were some 18 Memorandums of Information and Instruction concerning the project. All of these documents were drawn upon in the preparation of the Phase II project report. The Phase II project report consists of eight separate volumes under the following titles:

I. Introduction
II. Air Pollutant Emission Inventory
III. Air Quality Measurements
IV. Odors - Results of Surveys
V. Meteorology and Topography
VI. Effects of Air Pollution
VII. Opinion Surveys and Air Quality Statistical Relationships
VIII. Proposal for an Air Resource Management Program.

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VII. OPINION SURVEYS AND AIR QUALITY STATISTICAL RELATIONSHIPS

INTRODUCTION

Air pollution is primarily a social problem. Social considerations include, for example, the relative emphasis a community is willing to place on air pollution control in view of other pressing problems, the legitimate needs of groups and individuals for activities that produce air pollution, the degree of cleanliness of the atmosphere considered desirable, and the purposes and policies of a community. The nature and magnitude of air pollution control measures thus reflect the opinions and desires of the public and public officials as well as the technical facts that prevail.

Opinion surveys were conducted among public officials and the general public in an attempt to define the air pollution situation in the Interstate Air Pollution Study Area as men see it, for, as Medalia has said,[1] "If men define situations as real, they will be real in their consequences." This report relates data from studies in the fields of social science and physical science in an effort to better understand the total impact of air pollution on community life. The methods used were intended to promote this objective and to develop opinion surveys as an acceptable tool (unbiased or little biased) for air pollution program use. If such surveys are accepted, they will become an expansion of the democratic process, because the people will have broader participation in the affairs of their government.

The fact that opinions are considered here does not mean that possible effects of pollution on health are to be ignored or compromised. Rather, it means that opinions are considered in addition to technical information relating air pollution to adverse health effects. Obviously public opinions cannot be used to gauge reactions to such pollutants as arsenic, lead, and carbon monoxide, which are important to health and well being, but which even in dangerous concentrations may not be detected by the subjective human senses (i.e., smell, taste, sight, touch).

There is no doubt that opinions on a subject can be influenced by the nature and amount of attention given to it in mass media and other means of communication. The surveys reported here were conducted in the summer of 1963, before any extensive public information releases occurred in specific regard to air pollution in the Study area or to the extensive studies that were undertaken.

Two types of opinion survey reports were used; the first, a survey of public opinion,[2] and the second, a survey of the opinions of public officials.[3] Each of these surveys are summarized here. A third and major section of this report deals with a specialized use of the public opinion survey in which the results are related to chemical and physical measurements of air pollution.

PUBLIC OPINION SURVEY

As part of the Interstate Air Pollution Study, a public opinion survey was made by Southern Illinois University. The following are the results and conclusions of the University's report[2] on this survey:

"In the St. Louis Metropolitan Area in 1963, clean air at first glance apparently was more important to suburbanites than to city* dwellers: suburban residents cited clean air as something they liked about their area more frequently than did city residents; suburban residents, particularly in the Illinois area, also cited air pollution as a 'dislike' more frequently than did city residents. The city population, a large portion of which is non-white, was more concerned with other social problems, such as juvenile delinquency and unemployment. Other data repeats this pattern by showing that the non-white resident was less satisfied with his neighborhood than was the white resident, but that air pollution was not a significant cause of his dissatisfaction; this contrasts with the metropolitan area as a whole in which air pollution in the neighborhood was significantly related to dissatisfaction with their city or township as a place to live.

"Apparently, then, one community problem can be displaced as a cause of concern by the existence of other problems. This is directly supported by other data from the survey: to residents who ranked their communities as 'excellent' no problem was singled out as particularly serious; residents who ranked their communities as 'good,' 'fair,' or 'poor' listed unemployment and juvenile delinquency as most important; residents who ranked their communities as 'very poor' most often cited air pollution as the most serious community problem. No single problem appeared to be a determinant of the rating of a community as a place to live.

"The problem of air pollution can be masked or can mask other social problems. Certainly where it exists it can, depending upon the existence of other problems, be a considerable factor in the overall feeling of a resident about his community. St. Louis County residents, who thought no problem was very serious in their community, cited lack of recreation areas as their most serious problem. Juvenile delinquency was most important to St. Louis City residents; air pollution ranked fourth (of six problems). In Madison County, Illinois, air pollution ranked first.

"Other survey data showed that the residents' rating of the effectiveness of their officials was related to their rating of their city or town as a place to live, and was related to their perception of the seriousness of various problems.

"Although few persons reported that they had complained about any of the problems presented, there was a relation between those who wished to complain and those who gave a low rating to the effectiveness of their officials. It is also significant that those who thought air pollution was the most serious problem in their community were those who most frequently wished to complain. Other complaint patterns evidenced themselves in the survey. Those who wished least to complain were the highly educated, (presumably those living in communities with the fewest or least serious problems and with the least cause to complain) and the relatively uneducated residents, (presumably those living in areas having the most serious problems, but who may have been afraid to complain or who did not know how or to whom to complain). Those who wished to complain the most were in the middle

*In this section, "city" refers to St. Louis city; "suburbs" refers to the rest of the metropolitan area.

education bracket, (presumably those who are living in communities which experienced the problems to some degree, and who are articulate and knowledgable about making complaints). There was evidence, too, that the residents felt some problems could be more readily dealt with by complaint than others; e.g., you can call the police about a juvenile delinquency problem, but where can you make an effective single complaint about unemployment problems? Air pollution may fall into both categories. Where some local agency or official is strongly identified with air pollution more complaints are likely than in those areas where no focus of complaint exists.

"With respect to specific attitudes toward air pollution, almost 50 percent of the entire metropolitan population said air pollution was at least 'somewhat' bothersome, and in the Illinois segment two-thirds of the population so indicated. A consistent pattern of the perceived seriousness of the problem emerged for the three major-area divisions: St. Louis County considered the problem least serious, the Illinois counties considered it most serious, St. Louis City came between. Air pollution affected personal aspects of living more in Illinois than elsewhere, but even in St. Louis County 20 percent of the residents stated that air pollution affected their choice of jobs and affected household maintenance activities. For the overall area the number of residents who were affected in one or more personal aspects of living equalled the number who were 'somewhat' bothered by the problem. Nine out of ten residents thought air pollution adversely affected health, and the more highly educated made the connection almost unanimously. However, a large portion of those afflicted with ailments (such as lung and heart troubles and allergies), to which air pollution is strongly implicated as a contributory factor, stated that they were not bothered by air pollution.

"Forty percent of the overall metropolitan sample experienced air pollution in the 'neighborhood' and, since almost half were 'somewhat bothered,' many must have been bothered at work, on the way to work, or at some other activity away from home. Seasonally, the sample experienced air pollution most in the summer; this might be explained in terms of the types of sources which may exist in an area as well as by the fact that in summer people are out of doors more or are indoors with windows and doors open.

"In defining air pollution, more than 50 percent listed odor; smoke was second. The more serious a respondent considered air pollution, the greater were the number of listed definitions which he included for it.

"Factories and businesses were most often cited as the causes of air pollution and, as was the case with respect to definitions of air pollution, the more serious the problem was considered the greater were the number of causes cited.

"In summary, the citizens of Metropolitan St. Louis were well aware of air pollution as a problem and were bothered by it, knew what the components of air pollution were and what caused it, believed that air pollution adversely affected health, and were aware that certain aspects of their daily living were adversely affected by the problem.

"Data on the effectiveness of the mass media in communicating air pollution information showed a somewhat inconsistent pattern. Although the perceived seriousness of air pollution as a problem did not relate to a respondent's reading about pollution in the newspaper or hearing about it on television or radio, the interest of

the respondent in air pollution did relate to such exposure. Further, a considerable portion who were 'interested' did not perceive the problem as serious for them personally. With respect to exposure to the subject of air pollution in personal contact situations (rather than through the mass media) the data is consistent: perceived 'seriousness' and 'interest' both related to hearing or talking about air pollution with a doctor or in a community or neighborhood organization. However, whether hearing about air pollution caused the interest or the interest caused the respondent to talk about it could not be determined from the data.

"As might be expected, the more serious the resident thought air pollution was, the more he was inclined to feel that government and industry were not doing enough to control it. Industry was thought by St. Louis County and the Illinois counties to be making the least control effort, but St. Louis City residents gave industry a more favorable rating. Whatever their rating of industry and government efforts to control air pollution, some 90 percent of the residents believed that something should be done about the problem; the percentage was even higher among the highly educated and among those who believed their health was affected by pollution. Eighty-five percent of the residents were willing to pay $1 per year in taxes to control air pollution, and 66 percent were willing to pay a $5 a year increase in the cost of living for this purpose. The increased cost of living hypothetically was to be brought on by manufacturers having to install control devices.

"Although St. Louis city residents desired that the city government be responsible for the control of air pollution, a bistate control agency was generally supported in all areas. The more highly educated preferred a bistate agency. No other governmental level - Federal, State, local - was generally supported. More than two-thirds of the residents believed that their government officials would cooperate with other officials on the same side of the river in the development of an area-wide control agency for their side of the river, and slightly less than two-thirds of the residents believed that their officials would cooperate with officials on the other side of the river in developing an agency covering both sides of the river. In other words, if efforts to establish an area-wide control organization to tackle the problem of air pollution in the St. Louis area were to be made, the citizens say they would support it and the citizens believe their public officials would support it."

The following is synthesized from the same report:[2]

Awareness and concern with air pollutants arising from motor vehicles and affecting people in other vehicles is important in considering the future of mass transportation. An examination, primarily of St. Louis County information, reveals that 85 percent of the heads of households get to work by driving their own cars or riding with others, and that 58 percent take from 15 to 60 minutes to get to their destinations. The St. Louis County respondents also report that in their opinion, autos and buses are important causes of air pollution and that exhaust from "transport agents" is a major cause of neighborhood air pollution. They include motor vehicle exhausts in their definition of air pollution almost twice as frequently as do respondents from any other reporting area. This reaction tends to highlight the motor vehicle as a major recognized problem source and probably explains to a considerable degree the following observation in the report.[2] "It is interesting to note, however, that again, in each subarea, a greater proportion are 'bothered' by air pollution than recognize its existence in the neighborhood where they reside. This seems to indicate that residents of neighborhoods relatively free of air pollution are bothered by exposure to air pollution in other areas where they work, shop, or travel. On this basis the problem is area-wide rather than local."

PUBLIC OFFICIALS' OPINION SURVEY

Methodology and Response

A survey of public officials' opinion about air pollution[3] was made during the summer of 1963. Questionnaires were mailed by the Southwest Illinois Mayors Association to mayors and village presidents in southwestern Illinois and by the St. Louis County Municipal League to officials in St. Louis County. A reply from St. Louis City was not included in the following discussion because the large population of the city would have unduly biased treatment of the results from the other cities.

Of the 97 places in St. Louis County, 45 (including 20 city, village, and town clerks; 19 mayors and board chairmen), or 47 percent, returned the questionnaires. Their returns covered an area containing 54 percent of the total population in the incorporated area of St. Louis County. The response from places having less than 1,000 population was significantly lower than the response from areas having over 1,000 population. Only 37 percent of the population of the places under 1,000 was represented by returned questionnaires, as compared to about 55 percent of the population in places over 1,000 population. In Illinois, a better response was obtained; 17 officials (including mayors and village presidents), or 36 percent of the total number of places, including 68 percent of the population in the survey area, returned questionnaires. The percentage response was significantly higher from places over 5,000 population. Sixty-nine percent of these places, representing 76 percent of the population in such places, responded. On a total area basis, of the 143 places to which questionnaires were mailed, responses were obtained from 43 percent, covering 60 percent of the population in the surveyed area.

Awareness and Concern

Forty percent of the air pollution complaints received by public officials were in regard to domestic sources (backyard burning and home heating); 22 percent related to industrial sources; and 21 percent related to municipally controlled sources such as burning dumps, sewage, and incinerators. In Missouri, complaints about domestic sources were more numerous (56 percent) than in Illinois (30 percent). In Illinois, 28 percent of the complaints named industrial sources, over twice that in Missouri.

Sixty-nine percent of the officials, representing 75 percent of the population, indicated air pollution in their area was objectionable because it "soils or damages property" and "reduces property values." Fifty percent of the officials, representing 67 percent of the population, stated that air pollution "smells bad."

Officials reported very little activity by organized groups in their areas regarding air pollution matters, although there was somewhat more in Illinois than in Missouri. The officials themselves thought that more concern was felt about air pollution by doctors and housewives than by any of the other six categories of people listed. Officials felt that public concern was limited - an opinion different from that found in the public opinion survey, when public concern is related to the spectrum of community problems and various geographical areas.

Severity, Sources, Adverse Effects, and Control Action

Seventy-two percent of the reporting public officials did not think that their community had an air pollution problem. Twenty-eight percent, representing 51 percent of the population, stated that they either had a problem or that they did not know what the situation was. There were significant differences between the two states. In Missouri, 82 percent (71 percent of the Missouri population) stated they had no problem, whereas in Illinois only 47 percent (24 percent of the Illinois population) so responded. Perhaps, and understandably so, more officials reported sources of air pollution problems both within and outside their areas of jurisdiction than indicated they had an air pollution problem. It is significant in assessing the concern of the public officials that, of those reporting pollution sources located outside their areas of jurisdiction, 90 percent of the officials, representing 99 percent of the reporting population, named industrial sources as a major contributor to their area's problem.

Fifty-eight percent of all officials, representing 30 percent of the population, were of the opinion that neither the public nor the legislative body would support a tax for an air pollution control program. In places having a population of over 5,000, however, only 37 percent of the officials, representing 25 percent of the population, so responded.

The public officials were asked to express their opinion about the economic consequences of the enactment and enforcement of more stringent air pollution laws and regulations. One-half (representing two-thirds of the area's total population) felt that property values would probably increase; 42 percent (representing 64 percent of the population) felt that desirable types of employees could be attracted to the area more easily; and 37 percent felt that the area would become more attractive to industries. In view of the allegation sometimes made that air pollution control measures may drive industries away, it is significant that 70 percent of the officials (representing 70 percent of the population) felt that this was not a likely consequence of more stringent air pollution laws, and only 14 percent (representing 13 percent of the population) saw this as a likely consequence. Seventy-eight percent of the officials felt the area's economy would not be worse off, whereas 47 percent felt the economy would be better off with more restrictive air pollution laws.

Over 70 percent of the officials in both Illinois and Missouri thought that enforcement of more stringent air pollution laws would probably not decrease property values. Conversely, 67 percent of the Illinois officials (74 percent of the Illinois population) felt that an increase in property values would result from enforcement of air pollution laws. In Missouri, where air pollution is less severe than in Illinois, only 39 percent of the officials (56 percent of the Missouri population) thought so.

When asked about possible governmental arrangements directed toward control of air pollution in the metropolitan area, the plan most frequently named as that which would work well (70 percent of officials in areas comprising 76 percent of the population) was "all counties in the metropolitan area (in both states) should join together in operation of a program." Sixty percent of the officials in areas comprising 66 percent of the population felt that the following arrangement would also "work well": "A special agency should be established to serve the whole metropolitan area under terms of an interstate compact between Illinois and Missouri."

SURVEY CONCLUSIONS

Results of the two opinion surveys were compared for major points of agreement and disagreement. The following are the findings:

1. Both surveys indicated that the air pollution problem was more severe in the Illinois portion of the study area.

2. Both the public and the public officials were in general agreement concerning the nature of the air pollution problem. The public reported odors as the primary problem and placed smoke in second place. The public officials selected the same two major categories, but reversed the order of importance; they placed soiling and damage from air pollution at the top of the list and odors in second position.

3. Ninety percent of the reporting public indicated that something should be done about air pollution; however, 72 percent of the officials reported no air pollution problems in their areas of jurisdiction. This seeming major difference between the thinking of the public officials and those they represent results from a difference between officials' opinions in small population places as compared with places having over 5,000 population. In the more populous jurisdictions, there is good general agreement between the opinions of public officials and the public.

4. Public officials did not think their legislative bodies or the public would support taxes for governmental air pollution control programs; however, the public opinion survey indicated that 85 percent of the respondents would support a tax of one dollar per year for governmental air pollution control program purposes.

5. Both public officials and the public agreed that the air pollution control program that would serve well "would be one that joined the metropolitan area (in both states) together."

RELATIONSHIPS BETWEEN PUBLIC OPINION SURVEY RESULTS AND AMBIENT AIR QUALITY

Purpose

Opinions are legion; and, in spite of their qualitative nature, they guide many actions of both individuals and groups. This report attempts to quantitate public opinions about air quality to fulfill the following purposes:

1. To provide information in a form suited to development of an understanding of air quality and citizens' wishes regarding it.

2. To develop a tool that will assist in determining air quality goals.

3. To show relationships in an organized manner and statistical form between chemical and physical measurements of air pollution and public opinion.

4. To develop a methodology that will facilitate the use of results from public opinion and air quality surveys for finding ambient air quality levels acceptable to the public.

The following hypotheses were tested, some to a limited extent, in fulfilling the purposes:

1. The higher the air pollution levels, the greater is public concern about air pollution.

2. Certain air pollutant measurements are more closely related to public opinion than are others.

3. A certain combination of pollutants represents a combined stress effect relating to a certain percentage of people.

4. People are more concerned about short-term periods of exceptionally high air pollution than about the actual air quality itself.

5. People are more concerned about variations in air quality than about the air quality itself.

Methodology

In Nashville, Tennessee, low, medium, and high levels of pollutants such as sulfur dioxide, dustfall, and soiling were related to responses to certain questions in a public opinion survey. The methodology used in this study stems from the Nashville report[4] and builds on it. This new methodology is facilitated by the map grid system used by the Interstate Air Pollution Study. This grid system, which is described in detail in Memorandum of Information and Instruction No. 1, provides the key whereby any pollutant level, public opinion answer, or other survey information, including meteorological input, can be related on any time, area, or information-type basis.

This section of the report is based on physical and chemical measurements of air pollution from the Interstate Air Pollution Study (Volume III of the phase II report) and the public opinion survey carried out by Southern Illinois University.[2] Only six questions, No. 27, 28, 30, 31, 32, and 43, were selected for detailed analysis from the Southern Illinois University questionnaire (see Appendix A). The first five of these questions approach an ideal series that is well understood by the respondent, yields answers with no bias, brings forth true statements, results in mutual understanding, and provides reproducible results. These questions are called, for the purpose of this report, "a logic sequence." Question No. 27 asked the respondent to rate air quality in the area where he lives. He had seven choices and very little opportunity to give the matter much thought before making his rating. In question No. 28 he was asked to say what "air pollution" means to him, in his own words. The resulting definition is general in nature, but has followed a brief period of reflection provided by question 27. In question 30 he was asked to report what his neighbors consider air pollution to be. In this case he was not allowed a free choice, but had to select from a list of seven items. This question, since he reported what he thought his neighbors considered air pollution to be, focused on his neighborhood in a nonpersonal manner.

The next question, No. 31, was again personalized and had to do with the degree of "bother" due to air pollution experienced by the respondent. Question 32 focused again on air pollution in the respondent's neighborhood; it asked him point-blank whether there was or was not air pollution there. Question No. 43 asked the respondent to rank air quality in his neighborhood from a list of five terms ranging from "desirable" to "intolerable."

To facilitate relating the replies to the logic sequence questions to air pollution levels, the grid cell numbers of the locations where the respondents lived were added to the data processing cards containing the public opinion survey information. The grid cells used were 1,000 by 1,000 feet in size.

The Interstate Air Pollution Study reports Air Quality Measurements (Volume III) and Odors - Results of Surveys (Volume IV) contain the air quality data that were related to the public opinion survey results. The following air pollution measurements, made in 1963 and 1964, were used:

1. Suspended particulate matter, as measured by high-volume filter paper samplers

   a. Annual geometric means

   b. 99th percentile values (Highest 1 percent of the values obtained in a year).

2. Soiling index, as measured by the AISI strip filter paper sampler

   a. Annual geometric means

   b. 99th percentile values (Highest 1 percent of the values obtained in a year).

3. Sulfur dioxide, as measured by the volumetric West-Gaeke method

   a. Geometric means for the 1963-64 winter season (December, January, February).

   b. 99th percentile values for the 1963-64 winter season (December, January, February).

4. Sulfation as measured by the lead peroxide candle method

   a. Annual geometric means

   b. 99th percentile values.

5. Odor survey conducted by inspectors of the St. Louis Division of Air Pollution Control.

Since the public opinion survey did not cover exactly the same area as that covered by various pollutant sampling networks, it was necessary to ensure

coincidence for each type of pollutant with the respondent's place of residence. Figures 1 and 2 show the areas in which there were coincident data to use in this report from both the various aerometric networks and the public opinion survey. These data provided a base for comparison of results.

The relationship between air quality and public opinion was established through the geographical grid cell number. Graphs of air quality levels related to responses for selected opinion survey questions, on a 10,000-foot-square grid cell basis, indicated a statistical relationship between the two (Figure 3). Using this observation as a starting point led to examination of the relationship in more detail. This analysis, primarily geographic in nature, resulted in a good general understanding of people's response, but was not very detailed or precise. No attempt is made in this report to treat this grid cell approach by statistical analysis, although possibly it could be so treated.

The 10,000-foot-square grid cells were judged too large in that the respondents may not have lived in the average air-quality conditions of the grid cell. Respondents' locations were, therefore, based on 1,000-foot-square grid cells, and air quality levels were interpolated from isopleth maps on the same basis. These data were related to responses to questions in the public opinion survey.

In the 1,000-foot-square grid cell analysis, relationships between public opinion responses and air quality levels were examined on the basis of six to ten ranges of air pollution levels for each pollutant and the percent of individuals responding in certain manners in each. The geographic relationship is lost in this type of analysis, but statistical analysis is facilitated. By utilizing both approaches concurrently, a considerably better understanding of air pollution conditions is obtained.

Validity

The public opinion survey for purposes of this report is accepted as tested and reported by its authors.[2] There were 1,002 respondents in the public opinion survey sample; however, the sample size, when related to different air pollutants, varied from 487 for sulfur dioxide geometric mean to 785 for sulfation 99th percentile value. In the public opinion survey report differences were reported in the respondents' concern about air pollution in three major parts of the survey area, St. Louis County, St. Louis City, and Illinois. In St. Louis County, 11.1 percent of the people; in the City of St. Louis, 6.7 percent of the people; and in the Illinois area, 21.5 percent of the people placed air pollution in the highest priority position on a list of community problems. This fact, with its socioeconomic implications, influences the validity of the data for certain interpretations; however, the samples, both for the opinion surveys and surveys of air pollutants, come from discreet, self-contained areas and therefore have, on the grid-cell basis at least, self-correcting features for the effects indicated by these percentages.

The validity of the air quality measurements is reported in Volume III of this report. The use of isopleths is a method of interpolation that helps approximate true values. The adequacy of coverage of the sampling station networks and the validity of the meteorological data as they apply to long-term weather trends are also discussed in other volumes.

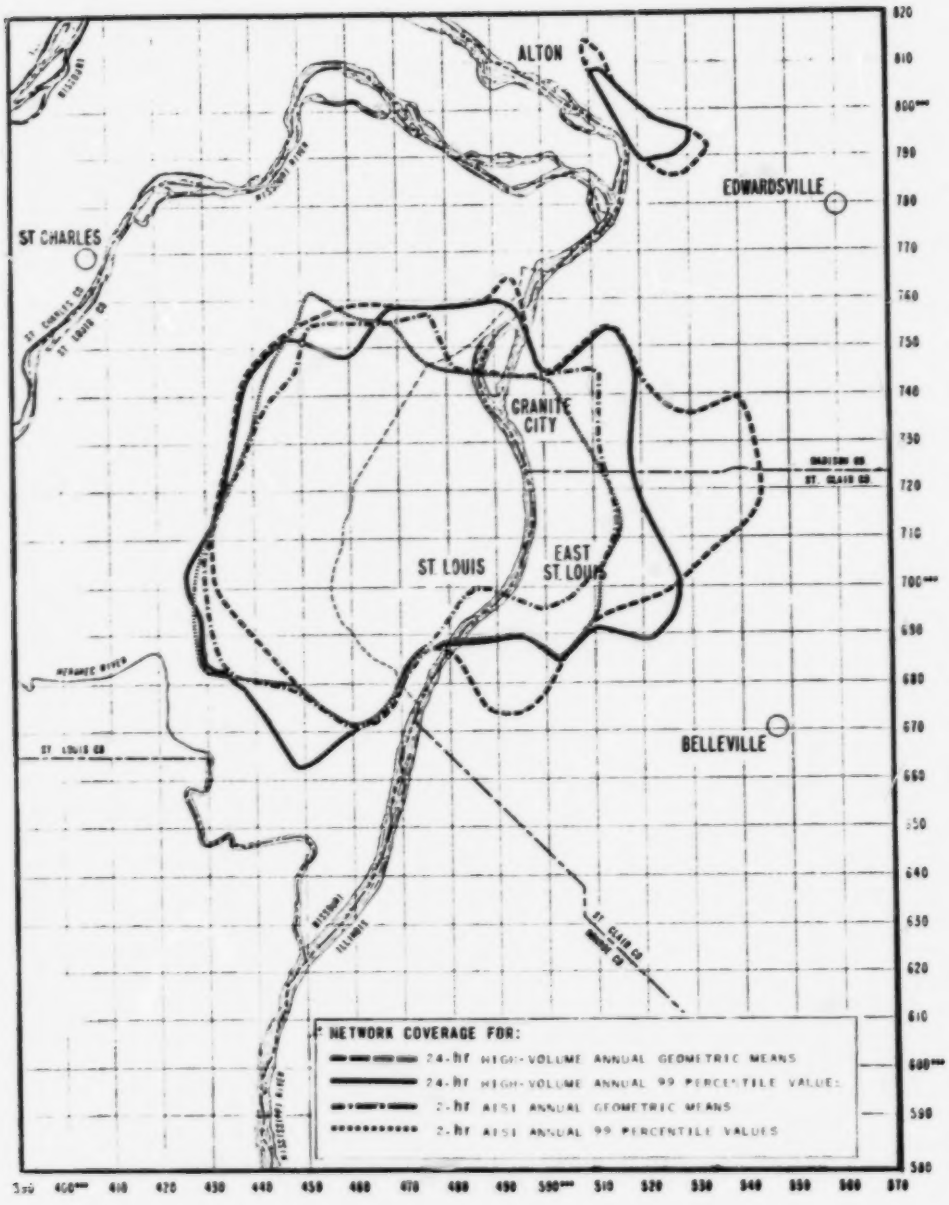


Figure 1. Measurement networks for suspended particulates.

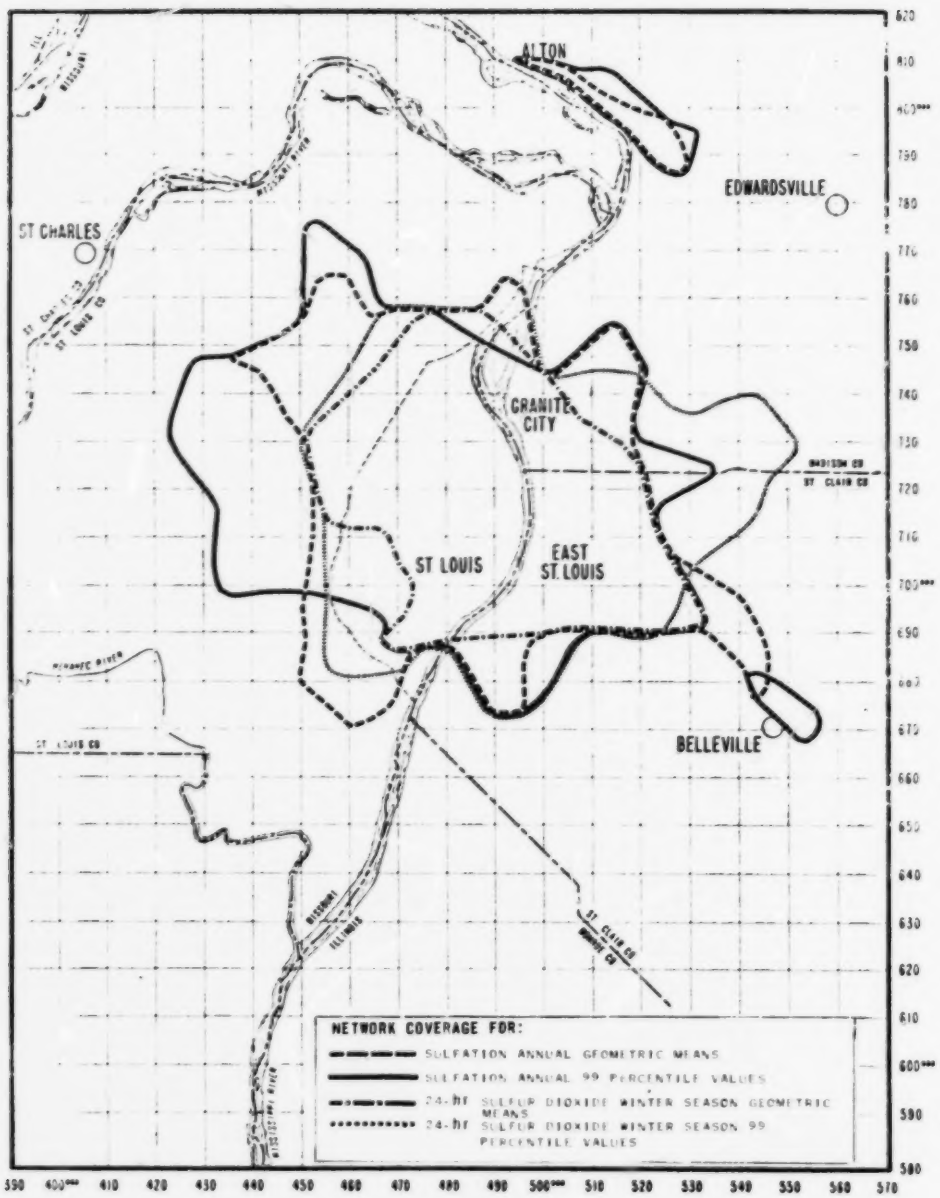


Figure 2. Measurement networks for sulfur compounds.

The relationship between the public opinion variable and the air quality variable, or variables, is not simple and cannot be fully explained. It is hoped that what is reported here will be of assistance to other investigators in the future. Starting with Smith's work in Nashville[4] and expanding his concepts to include as many as 10 levels of air pollution, rather than the three used there, provides some refinement in methodology. The curve of the relationship for a number of pollutants is recognized to be linear in the central portion of the pollution ranges measured. Also recognized, but not proved, is that the function is a combined stress response on the part of respondents to a single stress measurement, all influenced by outside forces. Methodology needs to be developed or adapted to allow for adequate analysis of this type of complex function.

Geographic Variation in Responses

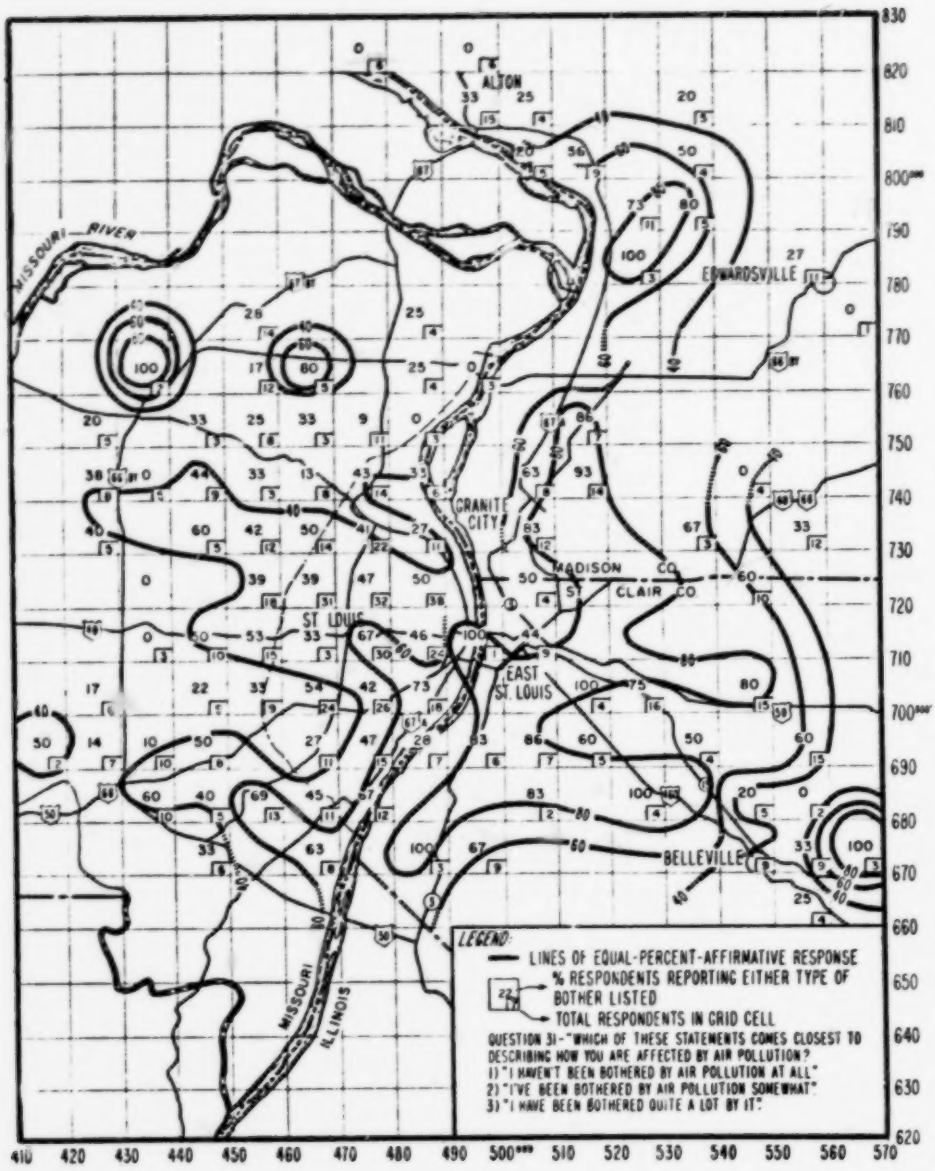
Survey question 31 relates to whether people were "bothered" by air pollution. (See Appendix A for questions.) The number of respondents in the grid cells are indicated by the boxed numbers in the lower right-hand corners of cells (Figure 3). The percentages appearing in the centers of the grid cells are percents of respondents bothered by air pollution, either "bothered somewhat" or "bothered quite a lot." The Illinois portion of the survey area showed the most respondents bothered, with 80 percent of the respondents bothered in parts of Granite City, East St. Louis, and a portion of the Hartford-Roxana-Wood River area (around grid coordinates 530-790*). The St. Louis central business district and the area adjacent to the Mississippi River do not present a coherent picture, possibly because of socioeconomic factors or too few respondents. The high percent of respondents bothered in grid cells 430-760 and 560-670 represents too limited a geographic area and too few respondents to be very meaningful.

Survey question 32 is "As you see it, is there any air pollution here in this neighborhood?" Again, the total number of respondents is indicated in the lower right-hand corner of the grid cell, and the percent affirmative responses is shown in the center of the cell (Figure 4). The geographic distribution is, in general, the same as that indicated by question 31 (Figure 3). The 75 percent isopleth, however, is somewhat smaller and shifted slightly from that for question 31. This map again points to the Illinois portion of the survey area as a major problem area.

Question 32 was also analyzed in its relationship to air pollution as defined by respondents in question 28. This analysis is reported on three maps (Figure 5, 6, and 7). These three maps show the results for those cases in which the respondents reporting air pollution in their neighborhoods defined air pollution as smoke, dust and dirt, or odors. On these maps, the fraction appearing in the lower right-hand corner indicates the numbers reporting air pollution in their neighborhoods and the total number of respondents in the grid cells. The figure in the center of the cell indicates the percent of those defining air pollution in one of the three specified manners:

1. Smoke. Figure 5 pertains to smoke pollution in neighborhoods. The zone of greatest concern is in the Illinois part of the survey area. The center of concern (75 percent isopleth) in the East St. Louis area is quite far to

*Grid cells refer to the area north and east of the designated point.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EDWARDSVILLE
GRANITE CITY
MADISON CO
ST CLAIR CO
ST LOUIS
EAST ST LOUIS
BELLEVILLE
MISSOURI
ILLINOIS
LEGEND:
LINES OF EQUAL-PERCENT-AFFIRMATIVE RESPONSE
% RESPONDENTS REPORTING EITHER TYPE OF BOTHER LISTED
TOTAL RESPONDENTS IN GRID CELL
QUESTION 31-"WHICH OF THESE STATEMENTS COMES CLOSEST TO DESCRIBING HOW YOU ARE AFFECTED BY AIR POLLUTION?
1) "I HAVEN'T BEEN BOTHERED BY AIR POLLUTION AT ALL"
2) "I'VE BEEN BOTHERED BY AIR POLLUTION SOMEWHAT"
3) "I HAVE BEEN BOTHERED QUITE A LOT BY IT."
410 420 430 440 450 460 470 480 490 500*** 510 520 530 540 550 560 570
830 820 810 800*** 790 780 770 760 750 740 730 720 710 700*** 690 680 670 660 650 640 630 620

Figure 3. Respondents "bothered" by air pollution (question 31).

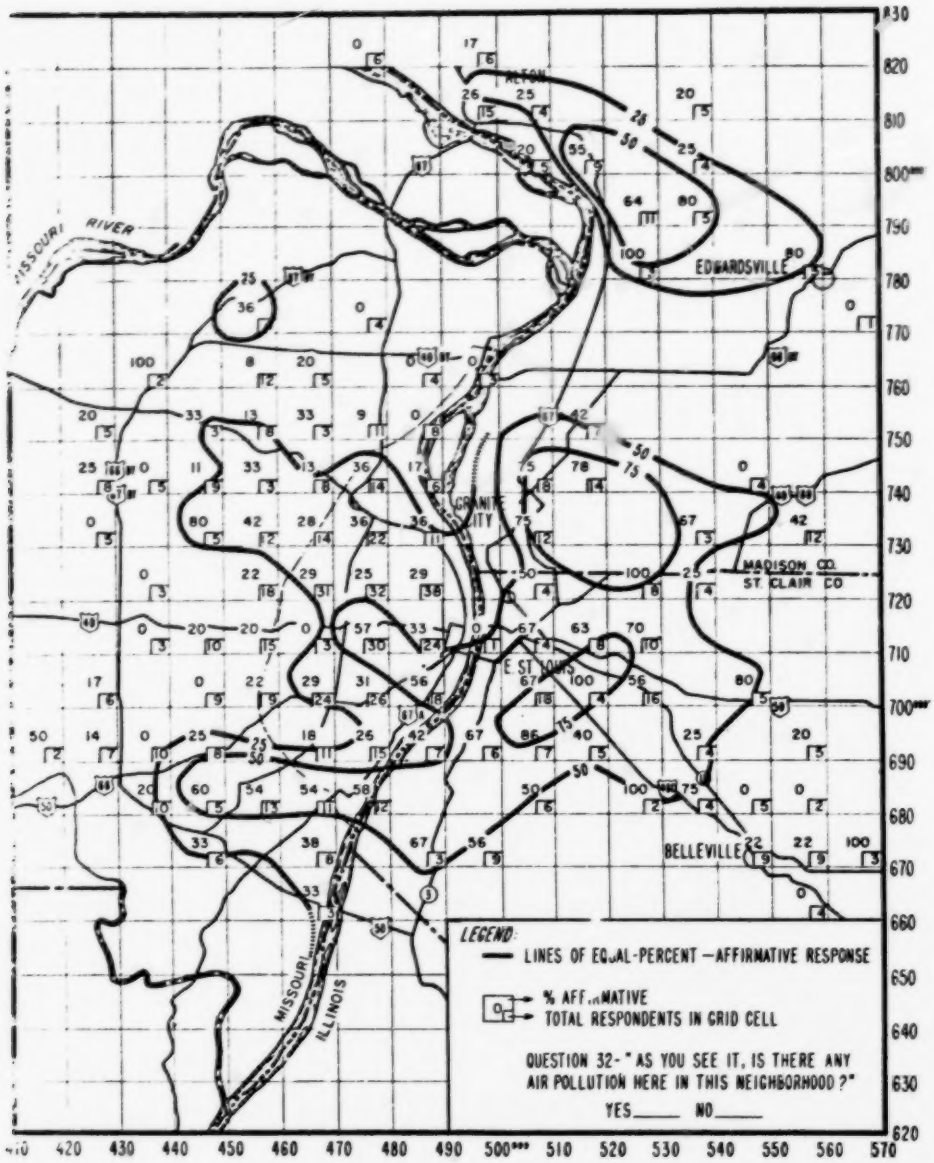
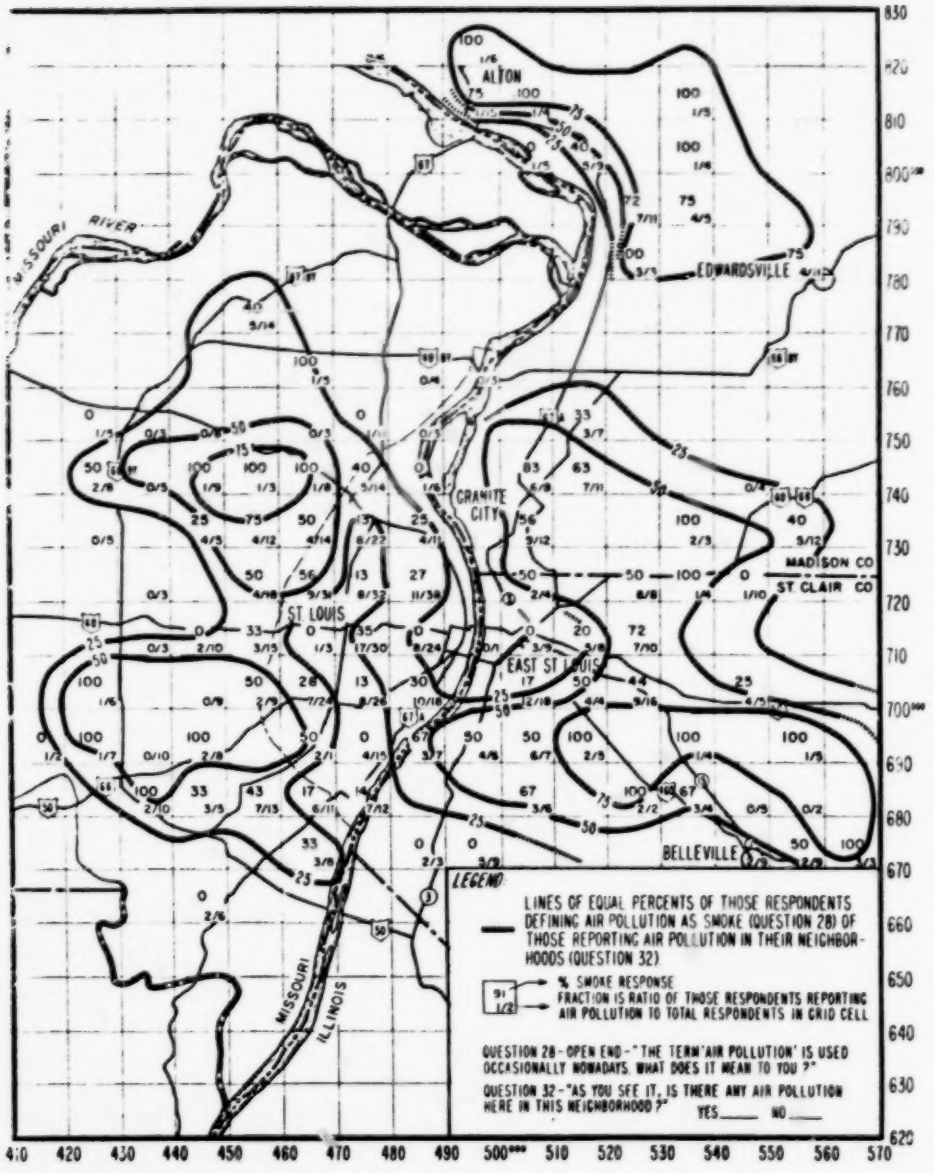


Figure 4. Respondents who believe there is air pollution in their neighborhood (question 32).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BELLEVILLE
MADISON CO
ST CLAIR CO
MISSOURI RIVER
MISSOURI
ILLINOIS
LEGEND
LINES OF EQUAL PERCENTS OF THOSE RESPONDENTS DEFINING AIR POLLUTION AS SMOKE (QUESTION 28) OF THOSE REPORTING AIR POLLUTION IN THEIR NEIGHBORHOODS (QUESTION 32)
% SMOKE RESPONSE
FRACTION IS RATIO OF THOSE RESPONDENTS REPORTING AIR POLLUTION TO TOTAL RESPONDENTS IN GRID CELL
QUESTION 28 - OPEN END - "THE TERM 'AIR POLLUTION' IS USED OCCASIONALLY NOWADAYS. WHAT DOES IT MEAN TO YOU ?"
QUESTION 32 - "AS YOU SEE IT, IS THERE ANY AIR POLLUTION HERE IN THIS NEIGHBORHOOD ?" YES____ NO____
410 420 430 440 450 460 470 480 490 500*** 510 520 530 540 550 560 570
830 820 810 800*** 790 780 770 760 750 740 730 720 710 700*** 690 680 670 660 650 640 630 620

Figure 5. Respondents who believe there is air pollution in their neighborhood and who define air pollution as "smoke" (questions 28 and 32).

the east and somewhat to the south of the city. The area of major concern in the Madison County area includes Alton and Edwardsville. There are pockets that appear to be significant in south and north St. Louis County, the latter near Route 70. The central business districts of St. Louis and East St. Louis, as well as a considerable section adjacent to the Mississippi River to the north, are not well defined, probably because of too few respondents.

2. Dust and dirt. Figure 6 relates responses concerning air pollution "here in this neighborhood" (question 32) to air pollution defined as "dust and dirt" (question 28). Again, the major concern was in the Illinois part of the Study area, with some areas of concern reported on the Missouri side. The central portion of the survey area is not well defined.

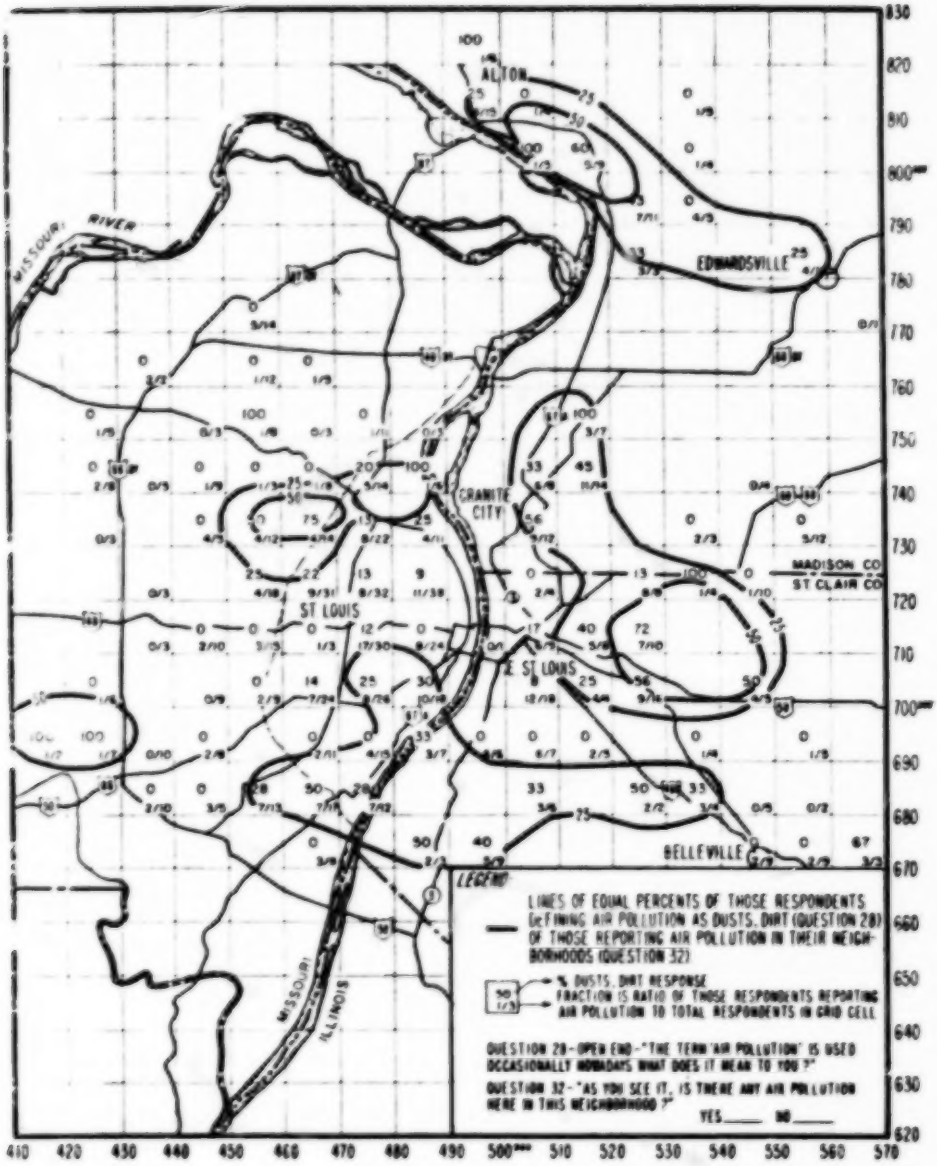
3. Odors. Figure 7 relates responses concerning air pollution "here in this neighborhood" to air poilution defined as "odors." The major areas of concern (75 percent isopleths) with odors as a neighborhood problem are south of the central business districts of St. Louis and East St. Louis to and beyond the south limits of the City of St. Louis. There are also major areas of concern southeast and northeast of East St. Louis, in the Wood River and East Alton area of Illinois, and in the northeast and southwest portions of St. Louis County.

Air Quality Measurements Related to Public Opinion

Four Questions, Four Pollutants - Table 1 lists the four pollutants considered, the number of air sampling stations for both geometric means and 99th percentiles, and the number of respondents to questions in the areas for which air quality data were available. Tables 2 through 5 report the results of the comparison in detail, and Table 6 summarizes Tables 2 through 5 statistically by using ratios of the regression slope to the product of the student "t" statistical test and standard error of the slope (see Appendix B for statistical criteria).

The ratios (Table 6) indicate the following order of greatest to least cause-and-effect relationships for the geometric means: high-volume sampler, soiling, sulfation, and sulfur dioxide volumetric measures. For the 99th percentiles the order is: high-volume sampler, sulfation, soiling, and sulfur dioxide volumetric measures. In other words, for mean pollution levels, high-volume sampler data are most closely related to opinions of the respondents, and volumetric sulfur dioxide measurements are least closely related to opinions of respondents about air pollution. These results are in general agreement with expectations with regard to the sensory perception (by sight, touch, taste, and smell) of the respondents to pollutants measured.

Use of Data as an Aid in Selecting Air Quality Goals - Figures 8 through 15 show in graphic form selected data from Tables 2 through 5. They show the relationship between responses to questions 27, 31, 32, and 43 and geometric mean and 99th percentile values of the four pollutant measurements. These figures can be used as an aid in selecting air quality goals insofar as those aspects of air quality that people perceive are concerned. The criteria used in selecting values from these data are subject to broad exercise of judgment. In this report the criteria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ST LOUIS
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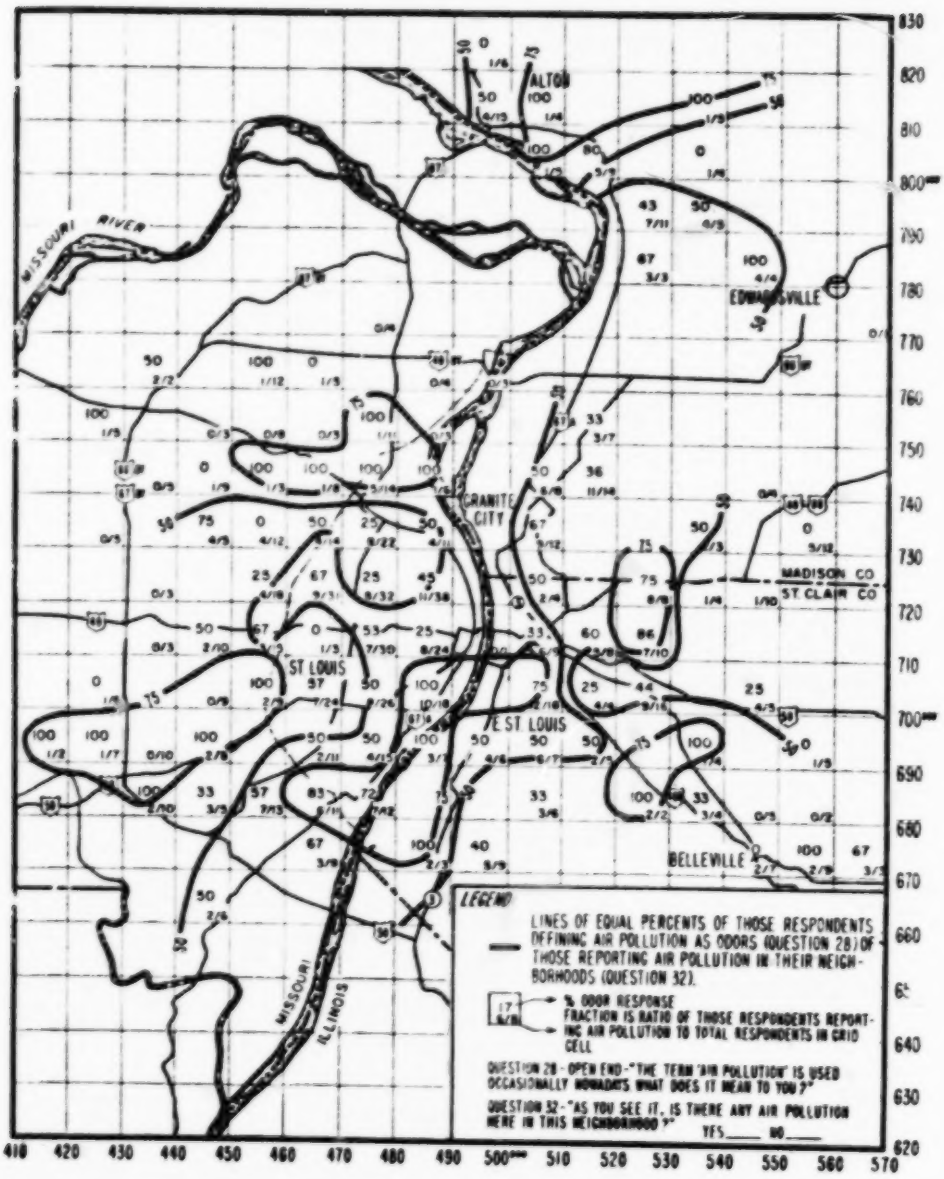
BELLEVILLE
MISSOURI RIVER
MISSOURI
ILLINOIS
MADISON CO
ST CLAIR CO
LEGEND
LINES OF EQUAL PERCENTS OF THOSE RESPONDENTS (re'FINING AIR POLLUTION AS DUSTS, DIRT (QUESTION 28) OF THOSE REPORTING AIR POLLUTION IN THEIR NEIGHBORHOODS (QUESTION 32)
% DUSTS, DIRT RESPONSE
FRACTION IS RATIO OF THOSE RESPONDENTS REPORTING AIR POLLUTION TO TOTAL RESPONDENTS IN GRID CELL
QUESTION 28-OPEN END-"THE TERM 'AIR POLLUTION' IS USED OCCASIONALLY NOWADAYS WHAT DOES IT MEAN TO YOU?"
QUESTION 32-"AS YOU SEE IT, IS THERE ANY AIR POLLUTION HERE IN THIS NEIGHBORHOOD?"
YES____ NO____

Figure 6. Respondents who believe there is air pollution in their neighborhood and who define air pollution as "dust and dirt" (questions 28 and 32).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MADISON CO
ST CLAIR CO
ST LOUIS
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MISSOURI
ILLINOIS
LEGEND
LINES OF EQUAL PERCENTS OF THOSE RESPONDENTS DEFINING AIR POLLUTION AS ODORS (QUESTION 28) OF THOSE REPORTING AIR POLLUTION IN THEIR NEIGHBORHOODS (QUESTION 32).
% ODOR RESPONSE
FRACTION IS RATIO OF THOSE RESPONDENTS REPORTING AIR POLLUTION TO TOTAL RESPONDENTS IN GRID CELL
QUESTION 28 - OPEN END - "THE TERM 'AIR POLLUTION' IS USED OCCASIONALLY NOWADAYS WHAT DOES IT MEAN TO YOU?"
QUESTION 32 - "AS YOU SEE IT, IS THERE ANY AIR POLLUTION HERE IN THIS NEIGHBORHOOD?" YES____ NO____

Figure 7. Respondents who believe there is air pollution in their neighborhood and who define air pollution as "odors" (questions 28 and 32).

Table 1. RESPONDENTS AND AIR QUALITY NETWORK STATIONS

Air quality measurement	Number of respondents in public opinion survey	Number of stations in air quality network
Suspended particulates		
High-volume sampler		
Geometric mean	739	17
99th percentile	716	17
Soiling index (AISI sampler)		
Geometric mean	595	12
99th percentile	638	12
Sulfur dioxide (volumetric)		
Geometric mean	487	20
99th percentile	609	20
Sulfation (lead peroxide)		
Geometric mean	711	41
99th percentile	785	41

Table 2. PUBLIC RESPONSES TO QUESTIONS RELATED TO PARTICULATE MATTER MEASURED ON ANNUAL BASIS BY HIGH-VOLUME SAMPLER

Suspended particulate matter concentration, $\mu g/m^3$	Responses to question 27		Responses to question 31		Responses to question 32		Responses to question 43		Number of respondents
	Satisfied,[a] %	Confidence limits[b]	Bothered,[c] %	Confidence limits[b]	Affirmative answers, %	Confidence limits[b]	Undesirable, excessive, or intolerable, %	Confidence limits[b]	
99th percentile values									
175 - 200	96.3	90 - 99	30.0	20 - 41	22.5	14 - 33	3.8	2 - 11	80
201 - 225	89.8	78 - 97	44.9	31 - 60	40.8	27 - 56	8.2	2 - 21	49
226 - 250	90.9	82 - 96	45.5	33 - 58	31.8	21 - 44	6.1	2 - 15	66
251 - 275	88.2	81 - 94	42.7	33 - 53	34.9	26 - 45	7.9	4 - 16	103
276 - 300	79.1	68 - 89	49.3	37 - 61	41.8	30 - 55	19.4	11 - 32	67
301 - 350	82.0	74 - 89	55.3	46 - 65	39.3	30 - 49	8.0	4 - 16	112
351 - 400	81.2	73 - 88	52.6	43 - 62	49.1	40 - 58	16.8	10 - 25	114
401 - 500	79.0	69 - 88	62.2	51 - 73	65.8	55 - 76	18.3	11 - 29	82
501 - 670	60.5	45 - 75	81.4	67 - 93	74.4	60 - 87	41.8	27 - 58	43
Geometric mean values									
60.0 - 67.5	100.0	94 - 100	40.0	28 - 53	26.7	16 - 39	0.00	0 - 6	60
67.6 - 75.0	90.6	82 - 96	33.8	23 - 46	27.0	17 - 38	6.80	2 - 15	74
75.1 - 80.0	89.8	81 - 96	40.0	29 - 52	27.1	17 - 39	7.20	2 - 16	70
80.1 - 85.0	88.2	81 - 94	45.2	35 - 55	37.6	28 - 48	7.60	3 - 16	93
85.1 - 92.5	92.3	82 - 97	42.3	29 - 57	32.7	20 - 47	7.7	2 - 20	52
92.6 - 100.0	76.1	65 - 85	50.0	38 - 62	44.4	33 - 56	16.7	9 - 27	72
100.1 - 125.0	80.1	73 - 86	57.3	50 - 64	45.3	38 - 53	14.7	10 - 21	183
125.1 - 150.0	71.1	60 - 81	84.2	75 - 92	73.7	63 - 84	28.0	18 - 39	76
150.1 - 220.0	60.3	47 - 73	64.4	51 - 77	78.0	66 - 88	33.9	22 - 47	59

[a]Strongly satisfied, satisfied, and mildly satisfied. [b]Confidence limits at 95 percent level.
[c]Bothered somewhat and bothered quite a lot.

Table 3. PUBLIC RESPONSES TO QUESTIONS RELATED TO SULFUR DIOXIDE MEASURED IN DECEMBER 1963 AND JANUARY AND FEBRUARY 1964

	Responses to question 27[a]	Responses to question 31		Responses to question 32		Responses to question 43[a]	
	Satisfied,[b] %	Bothered,[c] %	Confidence limits[d]	Affirmative answers, %	Confidence limits[d]	Undesirable, excessive, or intolerable, %	Number of respondents
99th percentile values							
0.050 - 0.100	72.4	65.5	52 - 77	44.8	32 - 58	19.0	58
0.101 - 0.133	71.8	79.5	65 - 90	76.9	62 - 88	28.2	39
0.134 - 0.166	80.0	69.3	58 - 80	60.0	49 - 71	18.7	75
0.167 - 0.200	84.9	40.8	34 - 48	37.6	31 - 46	9.4	181
0.201 - 0.233	80.7	52.5	44 - 61	45.8	37 - 55	17.8	120
0.234 - 0.266	82.4	45.3	35 - 56	37.2	27 - 48	10.5	86
0.267 - 0.417	91.8	44.0	30 - 59	38.0	25 - 53	8.0	50
Geometric mean values							
0.0100 - 0.0150	87.0	43.1	a	35.8	27 - 46	10.2	109
0.0151 - 0.0200	87.4	52.4	a	47.6	38 - 57	14.7	103
0.0201 - 0.0250	68.0	64.1	a	59.0	48 - 70	29.3	78
0.0251 - 0.0300	73.8	57.3	a	54.1	42 - 67	13.1	61
0.0301 - 0.0350	81.5	47.3	a	52.7	40 - 66	10.9	55
0.0351 - 0.0400	89.2	50.0	a	46.7	29 - 68	6.7	30
0.0401 - 0.0420	88.0	52.9	a	41.2	28 - 56	16.0	51

[a]Confidence limits not calculated.
[b]Includes strongly satisfied; satisfied; and mildly satisfied.
[c]Bothered somewhat and bothered quite a lot.
[d]Confidence limits at 95 percent level.

Table 4. PUBLIC RESPONSES TO QUESTIONS RELATED TO SULFATION MEASURED ON ANNUAL BASIS BY LEAD PEROXIDE CANDLE METHOD

Sulfation levels, mg SO_3/100 cm^2/day	Responses to question 27[a]	Responses to question 31		Responses to question 32		Responses to question 43		Number of respondents
	Satisfied,[b] %	Bothered,[c] %	Confidence limits[d]	Affirmative answers, %	Confidence limits[d]	Undesirable, excessive, or intolerable, %	Confidence limits[d]	
99th percentile values								
0.700 - 1.000	94.1	23.5	11 - 39	14.7	5 - 30	5.9	1 - 19	34
1.001 - 1.500	93.2	40.7	28 - 54	23.7	14 - 37	6.8	2 - 17	59
1.501 - 2.000	87.8	38.6	31 - 48	35.0	27 - 44	8.6	5 - 15	140
2.001 - 2.500	91.3	38.8	28 - 50	22.5	14 - 33	3.7	2 - 11	80
2.501 - 3.000	71.2	61.1	50 - 71	53.7	44 - 64	16.8	10 - 26	95
3.001 - 4.000	87.3	45.6	38 - 53	38.1	31 - 47	11.9	8 - 18	160
4.001 - 5.000	84.3	59.8	51 - 68	50.8	42 - 60	8.0	5 - 15	122
5.001 - 6.000	64.0	73.9	62 - 85	70.8	58 - 82	35.4	24 - 48	65
6.001 - 7.800	53.3	63.3	44 - 79	76.6	60 - 90	33.3	18 - 52	30
Geometric mean values								
0.500 - 0.750	89.8	42.8	35 - 51	30.4	23 - 39	7.3	4 - 14	138
0.751 - 1.000	85.0	44.8	37 - 53	37.0	29 - 46	12.3	7 - 19	154
1.001 - 1.250	80.6	51.6	45 - 59	46.3	39 - 53	15.3	10 - 22	192
1.251 - 1.500	84.9	54.5	46 - 63	41.5	33 - 50	8.9	5 - 16	123
1.501 - 1.750	76.7	79.1	65 - 90	69.8	54 - 83	26.2	14 - 42	43
1.751 - 2.000	62.8	69.8	54 - 83	76.7	62 - 88	32.6	19 - 49	43
2.001 - 3.700	70.6	55.5	32 - 76	83.3	62 - 95	27.8	12 - 56	18

[a]Confidence limits not calculated. [b]Includes satisfied, satisfied, and mildly satisfied.
[c]Bothered somewhat and bothered quite a lot. [d]Confidence limits at 95 percent level.

Table 5. PUBLIC RESPONSES TO QUESTIONS RELATED TO SOILING INDEX MEASURED ON ANNUAL BASIS BY STRIP FILTER PAPER (AISI) METHOD

Soiling index values, Coh/1000 lineal ft	Responses to question 27[a]	Responses to question 31		Responses to question 32		Responses to question 43		Number of respondents
	Satisfied,[b] %	Bothered,[c] %	Confidence limits[d]	Affirmative answers, %	Confidence limits[d]	Undesirable, excessive, intolerable, %	Confidence limits[d]	
99th percentile values								
2.000 - 2.500	98.1	38.5	25 - 53	26.9	15 - 41	1.9	0 - 10	52
2.501 - 3.000	91.1	44.3	33 - 55	30.4	20 - 42	5.1	2 - 13	79
3.001 - 3.500	94.0	39.2	26 - 54	25.5	14 - 40	6.0	2 - 17	51
3.501 - 4.000	87.5	43.2	33 - 54	34.1	24 - 45	6.9	3 - 15	88
4.001 - 4.500	81.8	49.1	36 - 62	43.7	31 - 58	16.4	8 - 29	55
4.501 - 5.000	78.9	53.5	44 - 63	45.6	36 - 55	13.1	8 - 22	114
5.001 - 6.250	89.6	46.2	35 - 57	35.0	25 - 47	11.3	5 - 21	80
6.251 - 7.500	78.6	57.1	38 - 74	60.7	38 - 78	22.2	10 - 42	28
7.501 - 10.000	60.7	78.6	67 - 88	70.5	58 - 82	37.7	26 - 51	61
10.001 - 12.300	69.0	56.7	36 - 76	83.3	68 - 93	20.0	9 - 36	30
Geometric mean values								
0.200 - 0.300	94.0	42.0	32 - 52	31.0	22 - 41	4.0	2 - 10	100
0.301 - 0.400	90.6	38.3	30 - 47	27.6	20 - 36	6.4	3 - 12	141
0.401 - 0.500	84.4	47.6	39 - 56	43.0	34 - 52	15.0	9 - 23	128
0.501 - 0.600	83.9	51.2	42 - 60	41.3	33 - 50	9.9	5 - 17	121
0.601 - 0.800	83.3	50.0	33 - 67	44.4	28 - 62	14.3	5 - 30	36
0.801 - 1.200	50.0	75.0	58 - 89	78.6	62 - 90	50.0	31 - 69	28
1.201 - 1.400	70.0	70.0	47 - 86	80.0	59 - 93	20.0	7 - 41	20
1.401 - 1.500	75.0	61.9	40 - 80	85.7	66 - 96	23.8	10 - 46	21

[a]Confidence limits not calculated. [b]Includes strongly satisfied, satisfied, mildly satisfied.
[c]Bothered somewhat and bothered quite a lot. [d]Confidence limits at 95 percent level.

Table 6. STATISTICAL ANALYSIS OF RELATIONSHIPS BETWEEN RESPONSES TO QUESTIONS AND MEASURES OF AIR QUALITY

Air quality measurement	Number of values	Question 27			Question 31			Question 32			Question 43			Ranks[a] of relationships	
		Std error of slope	Slope of regression line	R[b]	Std error of slope	Slope of regression line	R[b]	Std error of slope	Slope of regression line	R[b]	Std error of slope	Slope of regression line	R[b]	Geo mean air qual	99th percentile air qual
High-volume sampler															
Geometric mean	9	0.041	- 0.30	3.1	0.095	0.32	1.4	0.058	0.49	3.6	0.031	0.26	3.4[c]	1	-
99th percentile	9	0.011	- 0.08	3.1	0.012	0.11	3.9	0.015	0.12	3.4	0.015	0.08	2.3	-	1
Soiling index															
Geometric mean	8	9.3	-21.4	0.94	7.75	24.7	1.3	5.74	50.8	3.6	10.58	19.6	0.76	2	-
99th percentile	10	0.72	- 3.5	1.9	0.97	3.2	1.4	0.69	6.7	4.2	0.82	2.9	1.5	-	3
Volumetric sulfur dioxide															
Geometric mean	7	345.7	140.0	0.16	290.5	58.3	0.08	337.0	77.5	0.09	307.0	-134	0.17	4	-
99th percentile	7	15.7	74.9	1.9	52.5	-130	0.96	65.0	-98.0	0.59	25.7	- 62.0	0.94	-	4
Sulfation (lead peroxide)															
Geometric mean	7	3.58	- 9.8	1.1	6.99	8.5	0.47	5.13	26.1	2.0	3.82	10.6	1.1	3	-
99th percentile	9	1.33	- 6.2	2.0	1.60	6.6	1.7	1.52	9.8	2.7	1.22	4.9	1.7	-	2

[a] The R values for each measure of pollution were ranked for each question, with the highest R value being ranked as 1 and the lowest as 4. The four rank values for the four questions were added together. The air quality measurement with the lowest sum of rank values was ranked as 1 and the highest as 4 in this column. A rank of 1 indicates the closest relationship between the air quality measurement and responses to questions.

[b] R = Slope $\pm$ (standard error of slope x student "t" value). The absolute value is calculated and recorded. R less than 1 indicates no "cause and effect" relationship.

[c] Eight values were used to determine student "t" value.

used for selecting air quality goals were as follows:

1. With respect to question 27 (Figures 8 and 9), if 90 percent of the respondents were "satisfied" with air quality in their neighborhood (strongly satisfied, satisfied, or mildly satisfied), the air quality level was selected as satisfactory. These selected levels were used in steps 2 and 3.

2. In question 31 (Figures 10 and 11), the respondents were asked whether they had not been bothered at all, had been bothered somewhat, or had been bothered quite a lot by air pollution. The question does not refer only to the respondents' neighborhood. About 32 percent more respondents reported being bothered somewhat or quite a lot than reported being dissatisfied with air quality in their neighborhood. About 34 percent more respondents reported being bothered to some degree than described air pollution in their neighborhood as undesirable, excessive, or intolerable. This was taken to indicate that about 33 percent of the people bothered by air pollution were concerned about air pollution at some location other than in their neighborhood (e.g., at work or on the streets while traveling). This 33 percent was added to a basic assumed 10 percent of the respondents who were expected to be bothered by air pollution. Air quality goals were thus read off at the 43 percent frequency of bother from Figures 10 and 11.

3. In question 32 (Figures 12 and 13), the respondents were asked to answer yes or no as to whether there was air pollution in their neighborhood. A yes response was not considered to indicate a level of pollution that was necessarily objectionable or of concern to the respondent. About 24 percent more respondents said there was air pollution in their neighborhood than said they were dissatisfied with their air quality. About 27 percent more respondents said there was air pollution in their neighborhood than said air pollution in their neighborhood was undesirable, excessive, or intolerable. This was considered to indicate that about 25 percent of the respondents who said there was air pollution in their neighborhood did not find it particularly objectionable and in need of corrective action. This 25 percent was added to a basic assumed 10 percent of the respondents who were expected to state that there was objectionable air pollution in their neighborhood. Air quality goals were therefore read off of Figures 12 and 13 at the 35 percent level of affirmative response to question 32.

4. In question 43 (Figures 14 and 15), the respondents were asked to rank air quality in their neighborhood as desirable, acceptable, undesirable, excessive, or intolerable. It was considered that no more than 10 percent of the respondents should rank air pollution as undesirable, excessive, or intolerable. This value was used to read air quality goals off of Figures 14 and 15.

When these selected criteria are used, the annual mean and 99th percentile air quality goals indicated would be as follows:

1. Suspended particulate by high-volume sampler:

   Geometric mean - 78 to 85 micrograms per cubic meter.

   99th percentile - 240 to 268 micrograms per cubic meter.

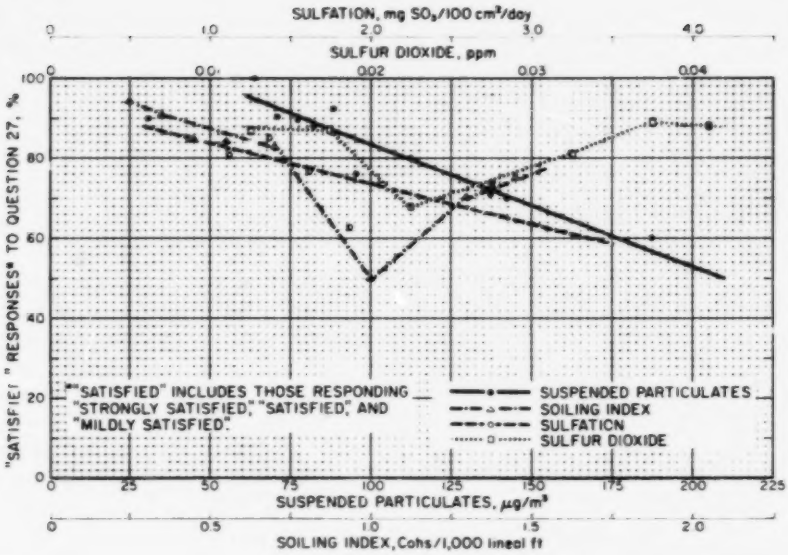

Figure 8. Relationship between response to question 27: "As far as this area goes, how would you rate the quality of air in this neighborhood right around here where you live?" and geometric mean values of four pollutants.

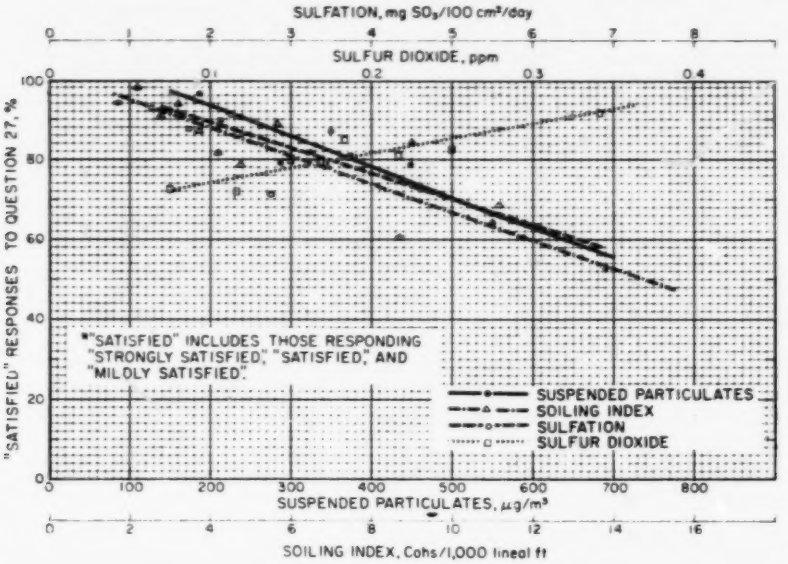

Figure 9. Relationship between response to question 27: "As far as this area goes, how would you rate the quality of air in this neighborhood right around here where you live?" and the 99th percentile values of four pollutants.

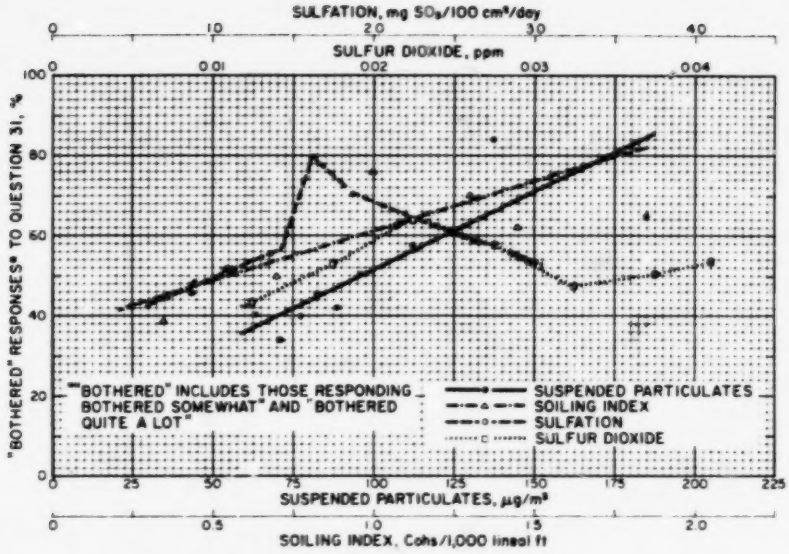

Figure 10. Relationship between responses to question 31 concerning degree of "bother" by air pollution and geometric mean values of four pollutant measurements.

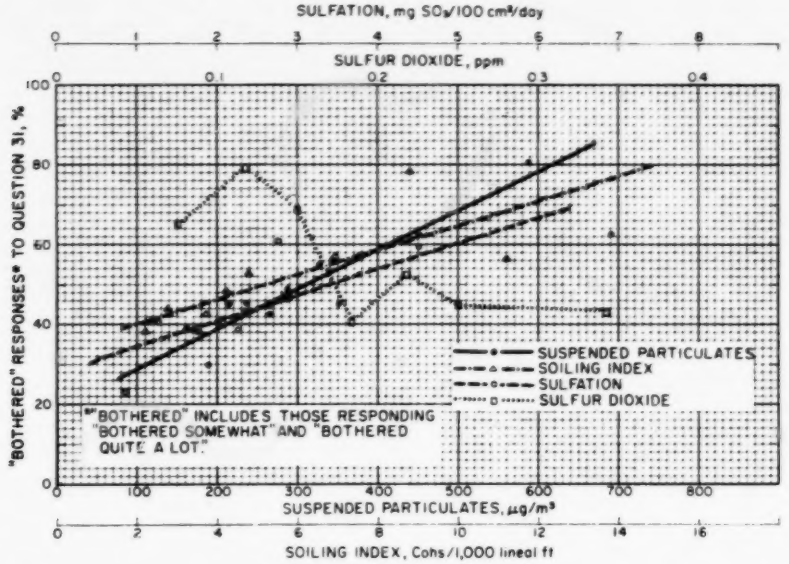

Figure 11. Relationship between response to question 31 concerning degree of "bother" by air pollution and 99th percentile values of four pollutant measurements.

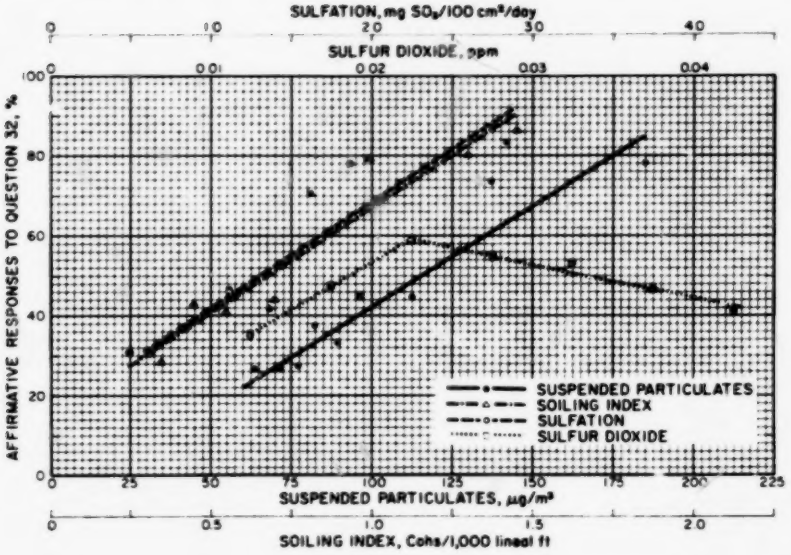

Figure 12. Relationship between response to question 32: "Is there any air pollution here in this neighborhood?" and geometric mean values of four pollutant measurements.

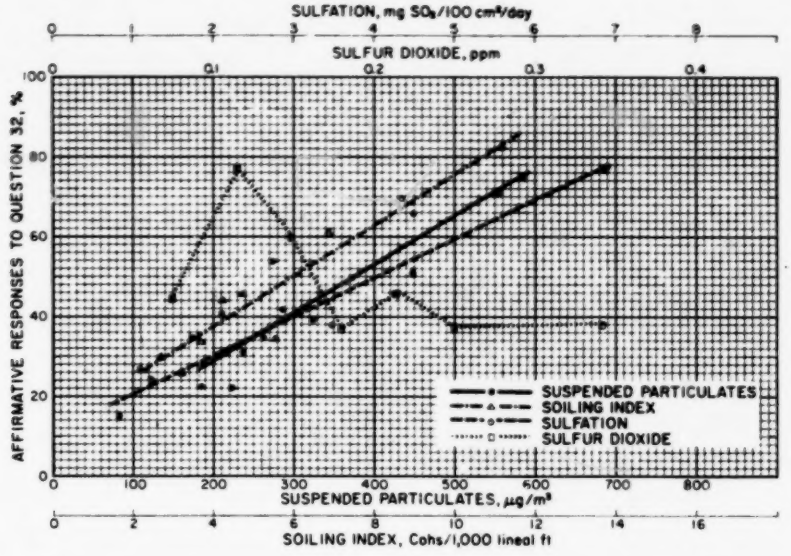

Figure 13. Relationship between response to question 32: "Is there any air pollution here in this neighborhood?" and 99th percentile values of four pollutant measurements.

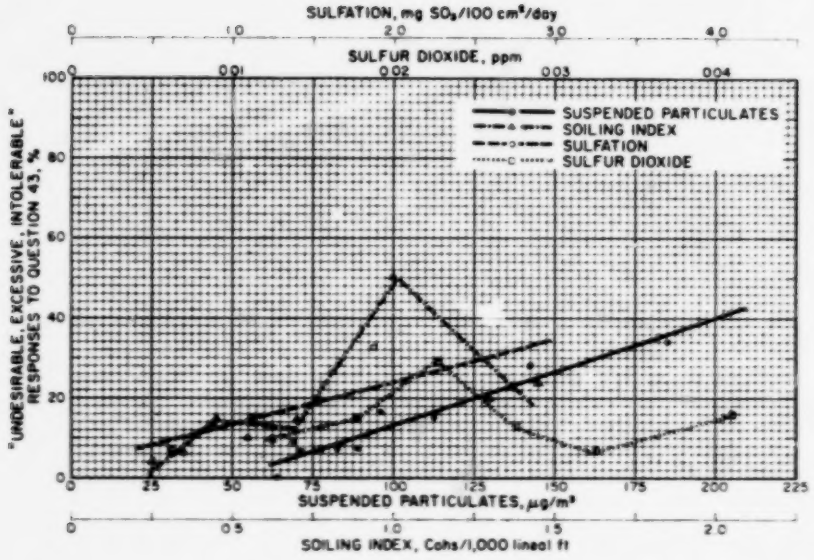

Figure 14. Relationship between response to question 43: "How would you rank the level of air pollution in this neighborhood?" and geometric mean values of four pollutant measurements.

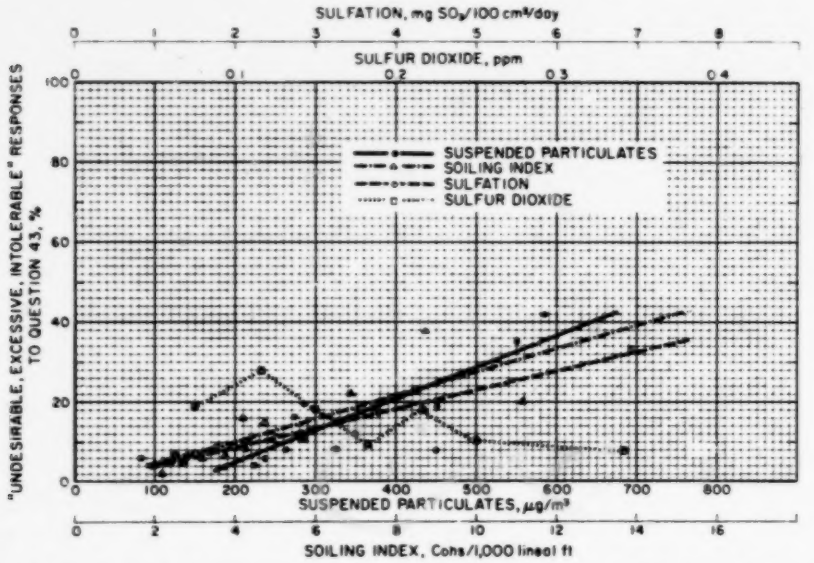

Figure 15. Relationship between response to question 43: "How would you rank the level of air pollution in this neighborhood?" and 99th percentile values of four pollutant measurements.

2. Soiling index by AISI strip filter paper sampler:

   Geometric mean - 0.37 to 0.45 Coh per 1,000 lineal feet.

   99th percentile - 2.8 to 4.0 Cohs per 1,000 lineal feet.

3. Sulfation by the lead peroxide candle method:

   Geometric mean - 0.42 to 0.73 milligram of sulfur trioxide per 100 square centimeters per day

   99th percentile - 1.9 to 2.4 milligrams of sulfur trioxide per 100 square centimeters per day.

The relationship between volumetric sulfur dioxide measurements and the respondents' answers were too erratic to yield meaningful values. The regression line slopes for volumetric sulfur dioxide were in an opposite direction to those for other pollutants in some cases, and reversals in the slope of the sulfur dioxide curves appeared. To try to find reasons for these occurrences, air quality levels for volumetric sulfur dioxide and sulfation were compared, as were the education and socioeconomic levels of those respondents living in the several levels of pollutants measured by these two methods. Results reported in Tables 7 and 8 indicate that the populations in each case are considerably different in their socioeconomic and educational-level characteristics. A comparison of air quality data indicated that the geographic distribution of the two pollutant measurements was also different. It would appear that the two measures of air pollution do in fact measure different things in some cases, but that people's response is only in part related to this difference.

Table 7. SOCIOECONOMIC LEVELS OF RESPONDENTS IN AREAS OF HIGHER AND LOWER MEAN SULFUR DIOXIDE LEVELS

Area of SO_2 geometric mean greater than 0.0250 ppm						Area of SO_2 geometric mean less than 0.025 ppm						Ratio of percents, $\frac{SO_2 > 0.025}{SO_2 < 0.025}$	
Income, dollars/yr	Respondents No.	Respondents %	Education, years	Respondents No.	Respondents %	Income, dollars/yr	Respondents No.	Respondents %	Education, years	Respondents No.	Respondents %	Income	Education
< 2,000	38	20.4	0-4	29	15.1	< 2,000	25	10.6	0-4	11	3.8	1.9	3.9
2,000 - 2,999	32	17.3	5-6	19	9.9	2,000 - 2,999	20	8.5	5-6	15	5.1	2.0	1.9
3,000 - 3,999	25	13.5	7-8	49	25.6	3,000 - 3,999	16	6.8	7-8	74	25.2	1.9	1.0
4,000 - 4,999	34	18.4	9-11	43	22.4	4,000 - 4,999	26	11.0	9-11	51	17.4	1.7	1.2
5,000 - 5,999	22	11.9	12	30	15.6	5,000 - 5,999	35	14.8	12	74	25.2	0.8	0.6
6,000 - 6,999	14	7.6	1-3 college	11	5.7	6,000 - 6,999	25	10.6	1-3 college	34	11.6	0.7	0.5
7,000 - 7,999	9	4.9	4 or more college	11	5.7	7,000 - 7,999	32	13.6	4 or more college	34	11.6	0.4	0.5
8,000 - 9,999	4	2.2				8,000 - 9,999	24	10.2				0.2	-
10,000 - 14,999	7	3.8				10,000 - 14,999	22	9.3				0.4	-
≥ 15,000	0	0				≥ 15,000	11	4.7				-	
Total	185	100	Total	192	100	Total	236	100.1	Total	293	100		

Concern About Variation in Air Quality - Table 9 reports the results of a test of whether people are more concerned about variations in air quality than they are in air quality itself (hypothesis 5). If people were more concerned about variations, the air quality variation data would appear in the table as an increase in percentages of people concerned as ratios between 99th percentile values (high

Table 8. SOCIOECONOMIC LEVELS OF RESPONDENTS IN AREAS OF HIGHER AND LOWER 99th PERCENTILE SULFUR DIOXIDE LEVELS

Area of SO_2 99 percentile $\geq$ 0.167 ppm						Area of SO_2 99 percentile > 0.167 ppm					
Income, dollars/yr	Respondents		Education, years	Respondents		Income, dollars/yr	Respondents		Education, years	Respondents	
	No.	%		No.	%		No.	%		No.	%
< 2,000	52	13.4	0-4	34	7.8	< 2,000	23	16.4	0-4	9	5.3
2,000 - 2,999	46	11.9	5-6	30	6.9	2,000 - 2,999	9	6.4	5-6	11	6.5
3,000 - 3,999	41	10.6	7-8	107	24.6	3,000 - 3,999	8	5.7	7-8	44	26.1
4,000 - 4,999	52	13.4	9-11	83	19.1	4,000 - 4,999	18	12.9	9-11	32	18.9
5,000 - 5,999	50	12.9	12	90	20.7	5,000 - 5,999	22	15.7	12	51	30.2
6,000 - 6,999	33	8.5	1-3 college	48	11.0	6,000 - 6,999	18	12.9	1-3 college	13	7.7
7,000 - 7,999	41	10.6	4 or more college	43	9.9	7,000 - 7,999	16	11.4	4 or more college	9	5.3
8,000 - 9,999	32	8.2				8,000 - 9,999	15	10.7			
10,000 - 14,999	27	6.9				10,000 - 14,999	9	6.4			
$\geq$ 15,000	14	3.6				$\geq$ 15,000	2	1.4			
Total	388	100.0	Total	435	100.0	Total	140	100.1	Total	169	100.0

Table 9. PUBLIC CONCERN ABOUT AIR POLLUTION AS RELATED TO VARIATIONS IN AIR POLLUTION LEVELS

Ratio of 99th percentile values to geometric mean values of air quality measurements	Percent of respondents			Number of respondents
	Bothered by air pollution (question 31)	Report air pollution in their neighborhood (question 32)	Report air pollution is undesirable, excessive, or intolerable (question 43)	
Suspended particulate, high-volume sampler				
2.00 - 2.79	56.1	62.2	18.5	82
2.80 - 2.99	51.0	38.6	11.8	153
3.00 - 3.29	59.3	55.0	19.5	160
3.30 - 3.99	45.5	34.5	9.4	235
$\geq$ 4.00	46.0	42.0	10.0	50
Volumetric sulfur dioxide				
4.00 - 6.99	62.6	59.3	18.8	155
7.00 - 8.99	55.0	51.2	11.2	80
9.00 - 11.99	51.0	44.0	19.0	100
12.00 - 13.99	44.7	42.8	14.5	56
$\geq$ 14.00	38.6	31.2	8.4	96
Sulfation (lead peroxide candle)				
1.00 - 2.09	49.7	43.8	13.1	153
2.10 - 2.69	49.1	42.2	13.4	173
2.70 - 2.99	48.7	42.7	10.3	117
3.00 - 3.99	60.9	51.0	16.6	151
$\geq$ 4.00	46.8	40.5	16.9	79
Soiling index (AISI sampler)				
6.00 - 7.99	60.7	59.0	21.3	61
8.00 - 8.99	45.5	42.8	8.1	112
9.00 - 9.99	47.7	42.6	15.7	155
10.00 - 10.99	47.3	36.0	9.3	150
$\geq$ 11.00	48.0	40.0	11.0	100

values) and mean values increased. With only one exception, and only slight variations through the ranges, all percentages for all questions and all pollutants decreased as the ratios increased. The exception was sulfation in the case of question 43, which increased slightly (from approximately 13 to 17 percent). Based on these findings, people are apparently not concerned primarily with variations in air quality, but are more concerned with the actual levels of pollutants (hypothesis 1).

Air Pollution Definitions Based on Terms - Table 10 reports the relationship between questions 28 and 30. Question 28 asked people to define air pollution in their own words, and question 30 asked them, by means of a closed-end question, what most people in "this area think of when they speak of air pollution." If the respondent's definition of air pollution is the same as he believes his neighbor's perception of air pollution in the neighborhood to be, each line item in the left-hand column of Table 10 will correspond with the corresponding boxed item in the same line in another column. Thus, "Smoke," reported under question 28, should find the "Too much dust and dirt" column with the greatest number of replies in it. In this case, the column reporting frequent bad smells in the air slightly

Table 10. RELATIONSHIP BETWEEN WAY RESPONDENTS DEFINE AIR POLLUTION AND THE WAY THEY THINK OTHERS DEFINE AIR POLLUTION

Words used by respondents to define air pollution[a] (question 28)		Definitions respondents believe "most people" think of when speaking of air pollution[b] (question 30)					
Word response category	Number of times response category given	Frequent bad smells in the air?	Too much dust and dirt?	Frequent haze or fog?	Frequent irritation of the eyes?	Laundry getting dirty on the line?	Frequent nose or throat irritation?
Smoke	412	291	278[d]	153	218	209	265
Exhaust gases	132	89[c]	82	42	62	52	83
Pollen	38	25	29	13	16	14	24[d]
Radiation	91	55	51	24	59	42	69
Chemicals (insecticides)	106	87[c]	62	36	56	43	67
Odors	483	407[c]	310	161	237	224	277
Dust, dirt	177	130	152[c]	65	81	111	111
Fog, smog	80	59	57	40[d]	41	37	50
Other unhealthy conditions	85	68	54	40	48	40	62
General contamination	159	122	94	48	79	67	91
Other	3	2	2	1	1	1	1

[a]Question 28: The term "air pollution" is used occassionally nowadays. What does it mean to you?

[b]Question 30: What do you think most people in this area think of when they speak of "air pollution"? Would you guess they mean...

[c]Should have greatest number of responses to question 30.

[d]Does have greatest number of responses to question 30.

overrides reports of "Dust and dirt." Reports of "Exhaust gases" under question 28 has the greatest number of affirmative responses under question 30 in the "Frequent bad smells in the air" column. Pollen reports are overridden slightly by odors and by dust and dirt. Radiation does not have a matching column under question 30. "Chemicals," under question 28, have the greatest number of reports in the "Frequent bad smells in the air" column of question 30. The "Odor" response under question 28 matches with "Frequent bad smells in the air" under question 30. The "Dust and dirt" category likewise matches. "Fog, smog" reports under question 28 do not match "Frequent haze or fog" under question 30. This would seem reasonable in view of the difference in meaning between the words. The other three categories under question 28 cannot be expected to show any relationship. Out of five categories in the responses to the two questions that could be expected to correspond, four of them, "Exhaust gases," "Chemicals (insecticides)," "Odors," and "Dust and dirt," do correspond, and the fifth, "Smoke," corresponds if one considers the split category of the question sections of question 30, "Frequent bad smells in the air" and "Too much dust and dirt." These data indicate that "Odors" and "Dust and dirt" are the two primary areas of concern to the public.

Air Pollution Definitions Based on Air Pollution in Neighborhood - Table 11 reports the relationship between questions 28 and 32. Four hundred respondents reported that there was air pollution in their neighborhoods, and 600 reported that there was no air pollution in their neighborhoods. Both groups of these respondents had defined air pollution previously in question 28. Odors were the primary definition item in each group, with 53.5 percent naming odors in the group reporting air pollution in their neighborhoods, and 44.8 percent naming odors in the group reporting no air pollution in their neighborhoods. Smoke was the second greatest definitional item of concern in both groups. Among those respondents reporting air pollution in their neighborhoods, 23.3 percent indicated "dust and dirt" as a third major definitional item. There was no clear-cut third most frequent definitional item among those respondents reporting no air pollution in their neighborhoods. The order of importance of air pollutants as people see them, from most to least, is odors, smoke,and dust and dirt.

Air Pollution Definitions Based on Odor Survey - Table 12 relates odor responses to questions 28 and 30A to results of the odor survey conducted by inspectors of the City of St. Louis Division of Air Pollution Control. Only respondents reporting air pollution in their neighborhoods were included. The geographic area was divided into two parts (high odor frequency and low odor frequency) on the basis of the inspectors' survey. The respondents in the areas of low odor frequency more often include odors in their definition of air pollution than do those in the area of high odor frequency, the reverse of what might be expected. A review of Table 13 indicates that this is probably related to differences in socioeconomic status, education, and priorities of problems between groups in these two type areas. This difference disappears when people's memories are stimulated by showing them cards listing air pollution definitional items as evidenced by response to question 30A. This is an important consideration in design and use of questionnaires. Of greater importance for the governments of the area are the implications of changing population characteristics in odorous areas. As people of higher socioeconomic status move into the renewed downtown portion of cities, where odors often occur, more complaints can be expected.

Table 11. COMPARISON OF WORDS USED TO DEFINE AIR POLLUTION BY RESPONDENTS WHO THINK THERE IS OR IS NOT AIR POLLUTION IN THEIR NEIGHBORHOOD

Terms used to define air pollution in response to question 28[a]	Respondents opinion on air pollution in his neighborhood in response to question 32[b]			
	Yes (400 respondents)		No (600 respondents)	
	People defining air pollution with terms given in left-hand column.		People defining air pollution with terms given in left-hand column.	
	No.	%	No.	%
Smoke	158	39.5	254	42.3
Exhaust gases	47	11.8	85	14.2
Pollen	18	4.5	20	3.3
Radiation	36	9.0	55	9.2
Chemicals (insecticides)	51	12.8	55	9.2
Odors	214	53.5	269	44.8
Dust, dirt	93	23.3	84	14.0
Fog, smog	25	6.3	55	9.2
Other unhealthy conditions	42	10.5	43	7.2
General contamination	72	18.0	87	14.5
Other	2	0.5	1	0.2

[a]Question 28 - The term "air pollution" is used occasionally nowadays. What does it mean to you?
[b]Question 32 - As you see it, is there any air pollution here in this neighborhood?

Table 12. OPINIONS OF RESPONDENTS ABOUT ODORS RELATED TO FREQUENCY OF ODORS REPORTED BY AIR POLLUTION INSPECTORS

Odor prevalence indicator	Areas of high odor frequency[a] as determined by odor survey, %	Areas of low odor frequency[b] as determined by odor survey, %
Frequency of unpleasant odor occurrence reported by inspectors	25.9	13.5
People who say there is air pollution in their neighborhood (question 32) and who include "odor" in their definition of air pollution (question 28)	46.7	63.6
People who say there is air pollution in their neighborhood (question 32) and who pick "frequent bad smells" as something most people think about when they speak about air pollution (question 30A)	88.3	76.3

[a]Inspector territories 1, 2, 3, 4, and 10 of the St. Louis Division of Air Pollution Control.
[b]Inspector territories 5, 6, 7, 8, 9.

Table 13. SOCIOECONOMIC LEVELS OF RESPONDENTS IN AREAS OF LOW AND HIGH ODOR FREQUENCY

Socioeconomic index	Class No.	Respondents			
		Low odor frequency areas		High odor frequency areas	
		No.	%	No.	%
Income, dollars/yr					
< 2,000	0	10	11.1	22	15.4
2,000 - 2,999	1	4	4.4	23	16.1
3,000 - 3,999	2	6	6.7	26	18.2
4,000 - 4,999	3	6	6.7	27	18.8
5,000 - 5,999	4	14	15.6	14	9.8
6,000 - 6,999	5	10	11.1	9	6.3
7,000 - 7,999	6	15	16.7	9	6.3
8,000 - 9,999	7	11	12.2	7	4.9
10,000 - 14,999	8	12	13.3	6	4.2
> 15,000	9	2	2.2	0	0
Totals	-	90	100.0	143	100.0
Education, yr					
0 - 4	1	3	2.6	21	13.5
5 - 6	2	5	4.3	15	9.5
7 - 8	3	36	31.5	34	21.6
9 - 11	4	12	10.4	39	24.8
12	5	31	26.9	26	16.6
1 - 3 college	6	13	11.3	13	8.3
4 or more college	7	15	13.0	9	5.7
Totals	-	115	100.0	157	100.0

Air Pollution Recognition - Table 14 reports relationships between responses to question 28, the open-end question defining air pollution, but limited to those respondents reporting air pollution in their neighborhoods (question 32) and levels for three types of pollutants. The increased recognition of air pollution in neighborhoods with more air pollution is clearly shown in all cases by the corresponding increases in the percent of "yes" responses to question 32. The "Dust and dirt" responses to question 28 relate, as one might expect, to air quality as measured by dustfall and high-volume samplers. Responses defining air pollution as "Smoke" did not vary greatly for the two ranges of soiling or suspended particulates as measured by the high-volume sampler.

Table 14. RANGES OF AIR POLLUTION LEVELS AND THEIR RELATIONSHIP TO RECOGNITION OF AIR POLLUTION AND ITS MEANING TO RESPONDENTS

Pollutant measurements and ranges of concentrations	Total respondents		Respondents who report air pollution in their neighborhood,[a] (question 32)		Respondents who define air pollution as "smoke" in question 28[b]		Respondents who define air pollution as "dust and dirt" in question 28[b]	
	No.	%	No.	%	No.	%	No.	%
Soiling index, Coh/1,000 lineal ft								
0.200 - 0.800	523	88.5	191	36.5	58	30.4	-	-
0.801 - 1.500	68	11.5	56	82.4	20	35.7	-	-
Suspended particulate, $\mu g/m^3$								
Less than 93.0	352	47.7	107	30.4	38	35.5	17	15.9
More than 93.0	386	52.3	217	56.2	84	38.7	60	27.6
Dustfall, tons/mi^2/month								
Less than 20.0	491	77.6	178	36.4	-	-	31	17.4
More than 20.0	142	22.4	96	67.6	-	-	26	27.1

[a]Question 32 - "As you see it, is there any air pollution here in this neighborhood?"
[b]Question 28 - "The term 'air pollution' is used occasionally nowadays. What does it mean to you?" Only replies of respondents who believe there is air pollution in their neighborhood are considered.

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APPENDICES

APPENDIX A - SELECTED QUESTIONS FROM PUBLIC OPINION QUESTIONNAIRE USED FOR ANALYSIS IN THIS REPORT

1. Question 27. As far as this area goes, how would you rate the quality of the air in this neighborhood right around here where you live? (HAND RESPONDENT CARD B.) Which statement on that card most closely represents your feelings?

Strongly satisfied	5- 1
Satisfied	2
Mildly satisfied	3
Mildly dissatisfied	4
Dissatisfied	5
Strongly dissatisfied	6
Don't know	y

2. Question 28. The term "air pollution" is used occasionally nowadays. What does it mean to you?

6-

Note:
Interviewer is to enter words used by respondents.

7-

8-

9-

10-

3. Question 30. What do you think most people in this area think of when they speak of "air pollution"? Would you guess they mean:

A. Frequent bad smells in the air?	Yes	12- 1
	No	2
B. Too much dust and dirt?	Yes	13- 1
	No	2

C. Frequent haze or fog? Yes 14- 1

No 2

D. Frequent irritation of the eyes? Yes 15- 1

No 2

E. When they speak of air pollution, do you think of laundry getting dirty on the line?

Yes 16- 1

No 2

F. Frequent nose or throat irritations? Yes 17- 1

No 2

G. Would you guess there are any other things people think of when they talk about "air pollution"? 18-

19-

4. Question 31. Which of these statements comes closest to describing how you are affected by air pollution? (READ CODES)

"I haven't been bothered by air pollution at all." 20- 1

"I've been bothered by air pollution somewhat." 2

"I have been bothered quite a lot by it." 3

5. Question 32. As you see it, is there any air pollution here in this neighborhood?

Yes . . (ASK A AND B) 21- 1

No . . (SKIP TO Q. 35) 2

6. Question 43. How would you rank the level of air pollution in this neighborhood? Would you say it is desirable, acceptable, undesirable, excessive, or intolerable?

Desirable 15- 1

Acceptable 2

Undesirable 3

Excessive 4

Intolerable 5

APPENDIX B - STATISTICAL CRITERIA FOR CHOOSING CAUSE-AND-EFFECT RELATIONSHIPS BASED ON USE OF REGRESSION SLOPE AND STANDARD ERROR OF SLOPE

1. If the linear slope is not equal to zero, the linear relationship between the dependent and independent variable is significant. If the slope equals zero, the two variables under scrutiny are independent.

2. The 95 percent confidence interval estimate of the slope is equal to:

   $s \pm (t)$(standard error of slope).

   s = Slope.

   t = Student "t" value for 95 percent confidence and $n-2$ degrees of freedom.

where:

   n = Number of values to determine regression.

3. Test $s - (t)$(standard error of slope) > 0.

   The linear slope will not be equal to zero if $\left[\frac{s}{(t)(\text{standard error})}\right] > 1.0$

4. In addition, the higher the ratio, $\left[\frac{s}{(t)(\text{standard error})}\right]$, the better the relationship.